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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN, THE NATIONAL IRONFOUNDING EMPLOYERS' FEDERATION, THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

Institute of British Foundrymen.

JUNE 20-23.

Institute of British Foundrymen:—Annual conference in Cardiff.

Gases and Inclusions.—II.

In our consideration last week of the question of gases and inclusions in cast iron, we concluded by referring to the simple case of gas being present as such in the form of a blow-hole. Gases may be present in the metal in combination with the metal itself, as oxides, nitrides, hydrides, etc. Under certain conditions the formation of these compounds is of very great industrial importance, while under others they are definitely harmful.

Finally, gases may be present in the metal in solid solution; they may dissolve in the metal and disappear as completely as a pinch of salt may disappear in a tumbler of water. The properties of the solution are, however, definitely changed thereby.

As is well known, the amount of any given gas which will dissolve in a metal depends very largely on the temperature and the pressure involved, and the changes in solubility which these changes involve create some of the most difficult problems to be met with in the art of founding.

In the cast metals, moreover, the gas formation during melting and subsequent processes is not the only source of gaseous inclusions. Actually, gas may be derived from the mould, and the condition of the metal with respect to gas is modified by annealing and heat-treatment operations. A definite movement is now on foot to treat gases as inclusions, which, in fact, they really are when the gas is combined with the metal to form a solid substance. It is, of course, recognisable as an inclusion, but it is equally unwanted when it exists in the gaseous state, either in solution or in a free state, as a blow-hole. From this point of view the inclusions may be regarded as solid, liquid, or gaseous, and graphite definitely becomes an inclusion. The carbonaceous character of the graphite and the way in which carbon may become oxidised is a fact of great significance in considering the whole question.

One of the most startling factors which has emerged from the developments in steel and non-ferrous metallurgy is the remarkable changes which very slight quantities of gas will bring about, quantities which the practical man would be tempted to ignore as of no consequence. There is, however, little doubt that some of the more baffling phenomena in the metallurgy of both grey and malleable cast iron will be solved by progress in this direction. In this respect the other branches of metallurgical activity offer very great encouragement to pursue the subject in the cast-iron field.

There is Still Time.

Last week Parliament granted a concession to the owners of coastwise shipping concerns by exempting oil-driven boats from the penny-a-gallon tax on heavy oils imposed by the last Budget. We would remind foundry owners that there is still time for them to make representations through their local Members of Parliament that the tax weighs very onerously on them also. It is perfectly obvious, as was pointed out by "The Times" last Friday, that the Chancellor has been misinformed on several material points, such as price fluctuations taken over recent years. It does seem to us an essential that the Government should be in possession of all germane facts as to the effects of the oil duties on the manufacturing costs and technical progress of the foundry industry, in order that sound judgment may be given, when considered in conjunction with other interests, such as coal, gas, electricity, national revenue and the like. Information derived from indirect sources, such as that given by the oil interests, will not carry the same weight as that supplied by the ultimate user. The Government cannot be blamed, if it assumes the attitude that "silence gives consent." From conversation with numerous foundry executives, it was strongly impressed upon us that the new tax is one which they cannot pass on to the customer, and it is thus a direct increase in manufacturing costs, running in average cases into several hundreds of pounds a year. Moreover, it penalises just those foundries which have made efforts to get themselves "out of the rut" by installing furnaces which they deemed to give better metallurgical control and lower handling costs. Finally, a quotation from "Macbeth" seems to give appropriate advice: "If it were done when 'tis done, then 'twere well it were done quickly"—as it will only be a matter of hours after the publication of this article that it will be too late to act.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

The Sand Question in Regard to Light-Casting Production.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I thank Mr. E. Wharton for his remarks published in your issue for May 18 in connection with my Paper on "The Sand Question in Regard to Light-Casting Production," and I would prefer to consider the letter more in the nature of criticism than a correction.

In the first place, I do not intend to dispute Mr. Wharton's opinion of the excellent work done by the British Cast Iron Research Association in connection with the co-ordination and standardisation of testing methods. In my Paper I clearly give an opinion relative to those essential points required for suitable routine control sand testing, namely:—(1) The apparatus must be as simple and robust as possible and capable of being used by any intelligent foundry operator, and (2) the results obtained should be capable of international comparison.

It is important that these two points be definitely connected with my remarks on co-ordination, for with them true co-ordination is not possible. Co-operative effort to-day, so far as scientific endeavours are concerned, must be more than nationalised, it must be international.

Dr. Skerl made a plea for international standardisation in 1929 in regard to sand-testing methods, and I had hoped that this would have led to some indication of work being done in this direction. Unfortunately, at this time the American Foundrymen's Association had already embarked and instituted standard methods for the routine control of sands whilst we in Britain had just commenced seriously to study the problem.

Something has to be done in the very near future, and in speaking of past work done by British investigators as being individual, I imply it from the viewpoint of international co-ordination. Mr. Wharton can be assured that I am by no means ignorant of the work done by his Committee and am hoping that the co-operative spirit will bear fruit in the production of international co-ordination and standardisation of testing methods for foundry sands.—Yours, etc.,

F. HUDSON.

Messrs. Glenfield & Kennedy, Limited,
Kilmarnock.
May 30, 1933.

Book Review.

Die Elektrische Warmbehandlung in der Industrie (Industrial Electric Heating), by E. FR. RUSS. Published by Verlag R. Oldenburg, Munich. Price Rm. 14.

Electric heating in industry has many applications. Annealing, hardening, tempering, carburising, enamelling, nitriding and many other uses are carried out to-day with conspicuous success. True, the economical side did limit a rapid extension of this modern development in the beginning; but present accomplishments show what an important feature electric heating is to become in the immediate future. This book is, therefore, a valuable contribution to what was, previously, a very mediocre literature.

The author writes anent the needs of practice, and treats his subject from the viewpoint of the prospective user and not of the furnace designer. The introduction explains the requirements to obtain low-tariff current, and how electric heat is to be used profitably. Then follows a survey of electric heating for ferrous and non-ferrous metals and other purposes. The next part treats, in general terms, of furnace

(*Continued on col.* 3.)

A Silicon-Carbide/Carbon Thermocouple.

At the New York meeting of the American Institute of Mining and Metallurgical Engineers, held recently, G. R. FITTERER described in a Paper entitled "A New Thermocouple for the Determination of Temperatures up to at least 1,800 deg. C." a thermo-electric couple of silicon-carbide/carbon made by running a silicon-carbide rod lengthwise through a carbon tube, which was closed and rounded at one end. The hot junction was prepared by tightly fitting the silicon-carbide rod into a socket on the inside of this closed end. Because of the large inside diameter of the tube, the two elements did not come in contact at any other point. This was insured by means of a split and tapered refractory ring, which separated the two at the open end of the tube. Cold junctions were made for both elements by means of water circulating through copper coils. Rubber tubing connected the two coils and only one inlet and one outlet were required.

Method of Calibration.

The most satisfactory method used for the calibration of this new couple was to measure its thermo-electromotive force at temperatures determined simultaneously with a platinum/platinum-rhodium thermocouple and an optical pyrometer, both of which were thoroughly standardised. The thermo-electric power of the C-SiC couple is approximately 30 times that of the platinum/platinum-rhodium couple, seven times that of the chromel-alumel couple, and five times as large as the iron-constantan couple. The chief advantage of the high thermo-electric power of this couple is that stronger and yet just as accurate industrial recording instruments can be used.

One decided advantage of the C-SiC couple is its reproducibility. Several differently-designed couples ranging from 2 ft. to 8 ft. in length have been prepared by the author and investigators in other laboratories. In every case the calibration line has been reproduced within less than 1 per cent. This not only shows that the couple is reproducible but also that the small variations in the temperature of the cold junction have but minor effects on the calibration of the couple. The maximum temperature to which the various couples may be used are:—C-SiC, at least 1,700 deg. to 1,800 deg. C.; Pt-PtRh, 1,400 deg. C.; chromel-alumel, 1,100 deg C.; and iron-constantan, 700 deg. C. Both elements of the C-SiC couple are highly-stable materials. The maximum temperature to which they may be subjected is probably somewhat below 2,700 deg. C.—the supposed melting point of silicon carbide.

Industrial Applications.

The temperatures of various liquid-steel baths were determined with the C-SiC couple which was immersed in metal baths for long periods of time during each series of measurements; such heating at high temperatures did not affect the calibration of the couple as indicated by the manner in which the various calibrations checked one another. Whenever possible the temperatures were checked by a Pt-PtRh couple but in such cases low-temperature melts—cast iron, for instance—were studied so as not to destroy the Pt-PtRh couple.

Two 8-ft. couples have been prepared and calibrated for steel-plant use and some very interesting data have already been obtained. Pig-iron temperatures in the runner and open-hearth tapping temperatures have been measured. It has long been the hope of the steel manufacturer to measure open-hearth temperatures previous to tapping, and the author has already determined that proper use of this couple can produce highly-satisfactory results. Temperature control in this regard could be extended to the tapping of each type of steel at a predetermined temperature interval above its melting point.

Catalogues Received.

Moulding Machines.—Foundry Equipment, Limited, of 15, Victoria Street, Westminster, London, S.W.1, have sent us an advance copy of their new 26-page catalogue. A first glance convinces us that page 26 (the index) should take the place of page 3 (conditions of sale) and *vice versa*, both on logical and psychological grounds.

The "Introduction," which is convincingly compiled, occupies two pages; it wisely stresses the fact that the exceedingly comprehensive list of moulding machines detailed cannot cover every possible requirement, and an offer is made to design special apparatus. We think some note might have been included in this section pointing out that the firm has exceptional experience for undertaking the complete mechanisation of foundries.

After a couple of pages devoted to metal pattern-plate making, the reader is taken progressively through hand-squeeze, pattern-drawing machines of the single-lever type; a special pattern drawing machine for pipes and gutters; hydraulic machines, produced in four sizes, fitted with under-sand frames to eliminate any tucking by hand. Their special field of application is that of shallow moulds. For deeper work a new range of hydraulic machines is illustrated and described. The P.D. type, of which there are at present two models, has distances between the table and the pressure plate of 18¾ and 23½ in. For moulds which require rolling over for stripping there are two more models of the T. type, which is often used in conjunction with the P.D. type, each making half a mould.

Next, rotary table machines are dealt with. The simpler has two stations, while a second range of four models has four. The final machine to be described is a compressed-air-actuated jolt squeezer, to take snap flasks up to 17 in. by 14 in. The balance of the catalogue is devoted to air compressors and receivers, hydraulic pumps and accumulators.

Recuperators for Industrial Furnaces.—The receipt of a well-printed and beautifully illustrated catalogue from the Carborundum Company, of Trafford Park, Manchester, served as a reminder to us of early efforts we made at designing furnaces. We wasted endless time in essaying to combine carborundum tubes with brickwork. Now all this is a thing of the past, as ready-made recuperators are available for attaching to existing furnaces or for incorporating in new designs. This is, indeed, a service which deserves the highest praise, as the design illustrated and described is both robust and ingenious. It is covered by patents granted to Mr. Fitch, and incorporates a really novel feature called a "Corebuster." We think Mr. Fitch must have been a foundryman, for a "Corebuster" is very much like a sand core set in a pipe mould, but instead of chaplets there are attached pins to maintain it in a central position. Naturally, this keeps gases passing through the tubes well against the inside surface. The catalogue contains 32 pages and is full of valuable technical data.

Soda Ash.—We have received from Imperial Chemical Industries, Imperial Chemical House, London, S.W.1, a four-page leaflet containing extracts of current opinions and comments. As a means of awakening preliminary interest in the subject of ameliorating the properties of cast iron, no better means could have been chosen.

(*Continued from col.* 1.)

construction, refractories, insulators, temperatures and temperature control. The final chapter describes, in some detail, various kinds of furnaces of German and American origin. The book is excellently illustrated, and is highly recommended to all who wish to inquire into the possibility of electric heating in their own industry. The work does not treat of the melting of steel or iron.

V. S.

The Technical Committee.*

By Jno. R. Hyde.

Introduction.

It was with very great pleasure that the author accepted the invitation to join in telling the Sheffield members something of the aims and objects of the Technical Committee of the Institution of British Foundrymen, which commenced in October, 1930. Although the Institute has always been fully practical, its Papers now have to embody a lot of matter dealing with modern theoretical aspects of foundry problems, so that it seems pertinent to stress the fact that the aim of the Technical Committee is directly utilitarian, and exists to deal with matters relative to productive industry.

Kindred societies at home and abroad have a habit of suggesting things affecting specifications, and advocating useful, or useless, theory or practice, so that a sober and sane committee is required to deal with such matters.

It is agreed that the Institute should take a live interest in considering the numerous matters which touch the foundry industry and be able to report to its members a considered opinion from a competent Committee. Those who have had experience with Committees will realise that a large Committee becomes unwieldy, so that the first idea to divide into a number of Sub-Committees immediately added to its usefulness and flexibility.

This Technical Committee is a direct successor to the Cast Iron Test Bar Committee, which was capably organised by Mr. John Shaw, and which carried to a successful conclusion the interesting work that it was called upon to perform, and it was perhaps in supporting this Cast Iron Specification that the necessity for a Committee to deal with other metals became apparent, and eventually the new Technical Committees proved the correct solution and the following five sub-committees were appointed:—(1) Steel; (2) cast iron; (3) malleable cast iron; (4) non-ferrous, and (5) sands and refractories. During last year two more have been added:—(6) Melting furnaces and (7) costing. One useful factor in working through a sub-committee is that comments are impersonal, both as regards individuals or firms, and consequently a much freer discussion is possible and an unbiased but fully-considered report is obtained. At meetings of the full committee to consider the reports of the sub-committees it is noticed that a very reasonable attitude has been accepted.

Cast Iron.

The first work of the Committees in 1930 was to collect the various specifications which were in use at that time, and by establishing definite specifications there is a measure of quality to work up to; perhaps it is a commercial ideal, and practical men on the Committee do not allow the wonderfully good results from one firm or laboratory in France, Germany or U.S.A. to lift that specification beyond commercial limits.

Having got a practical, sound and reasonable commercial specification by which to measure quality, the Technical Committee exists to examine the means and methods which help to produce such quality. Thus, the use of the microscope, and whether its evidence should form an essential point of commercial specification is being considered. So far, the Cast Iron Committee suggests that 16 typical photomicrographs be published, and circulated, and undoubtedly these would be referred to at lectures and discussions, and by this means the members of the Institute would become familiar with them.

This may be thought to be the thin end of the wedge to introduce micro-analysis into specifications. There is no doubt that for cast iron it will be very useful, but industry is immediately up against the expense of employing a special man and apparatus to obtain this information.

Another very interesting matter that the Cast Iron Committee have discussed was the standardising of foundry pig-iron. Every iron-founder will realise that the variety of pig-irons which he has at his command is a very important asset, and that to endeavour to standardise these would be to destroy their special qualities. The Admiralty specification for cast iron has also been under discussion.

Steel Sub-Committee.

This Sub-Committee obtained copies of various steel-casting specifications through the general secretary of the Institute during the 12 months. No less than 35 were received, and upon comparing these, it was realised that steel specifications were in reasonably good order, and did not contain any freak clauses. They were classified and it was found that the very great majority were based on British standard specifications.

A suggestion was passed on to the Sub-Committee for consideration that an export quality or lower specification should be introduced to meet foreign competition. It was found that lowering the mechanical test would not cheapen steel castings very much, but that relaxation of the chemical specification in sulphur and phosphorus would allow some reduction. There are, however, so many other things, such as tariffs and transport charges, that affect prices of British steel castings delivered overseas that the matter was left for the time being. More recently, a proposition had been made to raise the maximum stress figure, and to introduce a bend test for wearing surface material. The Committee, after very full discussion, considered this to be inadvisable.

Malleable Iron Sub-Committee.

Their first business was to collect and examine the various specifications which set out the commercial properties of malleable cast iron. The earliest appears to be B.E.S.A. K 17-18 of April, 1925, and it is a helpful feature that they did not encounter any unscientific specification from our grandfather's days.

The B.E.S.A. Specification of 1925 was revised in November, 1927, and the Institute was represented on that Committee, so it was decided that this B.E.S.A. Nos. 309 and 310 should form the basis of the work of the Sub-Committee.

Discussion showed the specification to be unsatisfactory in six chief points, one being that the standard was too low, and another that one standard-sized test-bar cannot represent various sizes of casting. This second is the old battle cry of the Cast Iron Test Bar Committee, and more applicable to malleable.

Non-Ferrous Sub-Committee.

Although non-ferrous metals are not made to a very great extent in Sheffield, it has been realised from many lectures, and also from the work of Prof. Desch when at Sheffield University, that there is a considerable variety and interesting work in connection with non-ferrous metals. When this Committee collected existing specifications they immediately realised that it would be necessary to simplify and classify them. Their foundation work is therefore to establish improved specifications, and at the same time try and standardise the method of casting the test-bar used, because practical men realise that comparisons between metals are of little value unless the test-bars have been cast and moulded under similar conditions. This Committee have also favourably received the suggestion to publish typical photomicrographs of standard non-ferrous castings, which will be of advantage like those put forward by the Cast Iron Sub-Committee, with getting the members of the Institute familiar with them, with advantage to both. There is a Non-ferrous Research Association in London, working on similar lines to the B.C.I.R.A., and no doubt co-operation would benefit all concerned.

In conclusion, the Technical Committee as now constituted forms a valuable buttress to the useful work of the Institute. Its work of rationalising statements, and its experience in organising research, will make it more useful every year.

One of the chief objects of this Paper is to ask for suggestions and criticisms.

* Notes presented at the Annual General Meeting of the Sheffield Branch of the Institute of British Foundrymen as a basis for discussion.

Scottish Steel-Foundry Industry.

What some industrialists regard as an extremely serious situation has arisen in the steel-castings industry, and may result in a considerable number of men losing employment. The crux of the situation is that within the past few weeks prices of British steel castings have been heavily increased, in some cases by as much as 50 and 60 per cent. As a result of this, buyers of steel castings may be compelled to go to the Continent for their supplies, which they can secure at slightly lower rates, despite the tariff which the Government imposed on the foreign products.

One buyer said: "During the past month or two the price of steel castings has jumped with alarming rapidity. It is a general advance throughout the industry which the manufacturers decided upon after the tariff had been imposed on foreign material.

"Several weeks ago I was in a position to secure a certain commodity at 19s. 6d. Now I have to pay 32s. 6d. for it. The position is very complicated.

"Say an engineering firm received a contract from abroad several months ago to equip a sugar factory with machinery at the prices then prevailing in the British market. The work commences, and they discover that their quotation cannot possibly show a profit if they have to pay the increased rates now asked for steel castings.

"What will the firm do? So long as the contract does not stipulate that the machinery and equipment must be British, the contractor is going to the Continent for the cheaper product. He cannot do anything else in the circumstances. That means that the steel manufacturers in order to raise the market prices for their goods are going to drive away trade from this country."

A well-known firm of steel manufacturers in Scotland said that prices for steel castings had been ridiculously low for a long time. "Buyers," said the head of the firm, "have had their own way for years. Owing to keen competition in the past steel manufacturers were compelled to cut their rates with the direct result that the industry was manufacturing the goods at a loss.

"But prices had to be adjusted. The Government imposed a tariff on foreign products to assist our industry and, naturally, they left the manufacturers at home to put their own house in order. We are now in the course of putting the house in order, hence the reason for an increase in the prices of steel castings."

Another manufacturer said: "An important meeting is taking place in London to consider the prices generally. I understand that the meeting will discuss the position and attempt to ease the complications which have arisen. There is no doubt that the matter is causing grave concern, but in reorganising an industry these things cannot be avoided. The steel founders do not for one minute desire to do anything that will have the effect of driving trade away. What we want is to secure more orders."

XUM

Grey-Iron Castings.

At a recent monthly meeting of the West Riding of Yorkshire Branch of the Institute of British Foundrymen, held at Bradford Technical College, under the chairmanship of Mr. A. S. Worcester (Huddersfield), a Paper on the subject of "Grey-Iron Castings" was contributed jointly by Mr. F. K. Neath, B.Sc., and Mr. H. F. Poole, of Keighley.

The authors made their observations of a more or less general character in order to provide material for discussion. It was pointed out that modern demands on the ironfoundry were becoming increasingly specialised, rendering the task of the jobbing founder much more intricate. With regard to light castings, there was a great deal of attention being paid to the surface finish in view of the requirements for enamelling, plating and painting, and such castings demanded careful control of moulding sand, coal dust and facing materials.

In the general engineering castings, said the authors of the Paper, the engineer was gradually making each type of production a special casting calling for closer knowledge of the materials used than hitherto. For castings which were required to stand up to high duty it was now the rule for specifications regarding composition, transverse and tensile strength, Brinell hardness, etc., to be issued. Considerable success had been achieved by foundrymen in the use of steel scrap in the cupola charges. Such mixtures, if correctly controlled, would give a metal lower in total carbon than was normally obtained from ordinary pig-iron charges. In some cases it was found that the use of refined pig-iron (usually made from a steel-bearing charge) was more convenient than the direct use of steel in the casting mixture.

Machine Tool and Automobile Castings.

In products such as machine-tool castings, where a hard-wearing sliding face was required, a considerable improvement had been effected by the use of the above-mentioned class of mixture with, where necessary, the application of denseners on the wearing faces.

In the motor-car industry, proceeded the lecturers, very close specifications were often in force. The requirements for cylinder castings were a sound, close-grained product, readily machinable and with a hard-wearing bore. The present fashion, or taste, in regard to metal composition was a low-phosphorus metal as distinct from the 0.8 to 1.0 per cent. phosphorus material commonly used ten or more years ago. The higher speeds and pressures used in present-day motor-cars had resulted in greatly increased wear in the cylinder bores. It should be pointed out that as far as could be ascertained from laboratory tests a 1 per cent. phosphorus metal was a better wear-resisting metal than lower phosphorus metal. Some engineers, however, objected to the high-phosphorus type owing to the difficulty in getting castings free from porosity.

In regard to piston rings, etc., in addition to ordinary cast iron, we now had hardened and tempered cast iron and also case-hardened cast iron. It was interesting, said the authors, to note that in Bradford the latest development was that of a firm who were making piston rings by the single-cast method, by which each ring was a separate casting as distinct from the pot casting (sand cast or centrifugally cast).

There were a number of specifications for automobile castings, proceeded the lecturers, which were similar to American specifications, and called for metal with a high total carbon content —over 3.4 per cent., for instance. Such metal was very prone to porosity and open grain in bosses and thicker sections unless closely controlled.

Defects in Castings.

The question of porosity was one of the chief causes of waster castings and was closely associated with shrinkage and drawing. There was need for a considerable amount of research into this question. The actual overall shrinkage of cast iron was fairly well known but the mechanism of solidification, with its contractions and expansions, was not fully understood. Some German investigators, for instance, had shown that the expansion of cast iron on solidification could take place either immediately the metal was solid or at the lower critical point—pearlite point. Their experiments had shown quite clearly that the gas content of the molten metal influenced this phenomenon.

DISCUSSION.

Considerable discussion followed the address, mostly in the form of questions and answers on points of detail arising out of experiences quoted both by the authors of the Paper and by various members present.

Mr. W. G. Thornton asked whether the authors could explain how it came about that two irons of the same analysis, cast under exactly the same conditions, could give results of five tons difference in tensile strength?—a matter which had occurred a number of times when he (Mr. Thornton) was engaged on Diesel-engine cylinders. In regard to phosphorus in cylinder castings, his feeling had generally been that if one got above 0.3 per cent. phosphorus one was getting into the danger zone. In regard to the growth and burning of fire bars, it might be interesting if the authors could go more into detail as to what actually took place. Mr. Thornton said he did not entirely agree with the authors' contention in regard to coarse and fine-grained iron.

What is meant by Hardness.

Mr. H. J. Young (Bradford) said, as a new member of the West Riding Branch, he had been greatly interested in the Paper and wished to compliment both the authors and the Branch on its value. It had, indeed, been a Paper so full of ideas that to discuss it adequately might fill up the time of a couple of sessions. Mr. Young said he was not quite certain phosphorus gave fluidity so much as giving more carrying power; he felt there was perhaps too much loose talk of fluidity. Mr. Young did not consider the addition of nickel was of much value in the average foundry, whatever may be its use in certain castings for peculiar purposes. In the matter of hardening of cast iron in relation to wear, he often felt that people talked a good deal about hardness without realising fully its import. He had himself seen irons which one could not cut with a hacksaw, but which were soft under the Brinell test, and, on the contrary, he had seen irons which could be easily cut, yet were much harder under the Brinell test. In regard to the matter of phosphorus percentage, he thought the research authorities need not waste much time over this. He had himself made hundreds of castings with a ½ per cent. phosphorus and never saw any difference. On the subject of oxidised iron, Mr. Young thought sometimes what was called by this name was iron very low in manganese.

Wear Properties of Cast Iron.

Mr. H. W. Swift (Bradford Technical College) remarked that it was easy for the engineer to make demands, but not always so easy for the foundryman to meet them; but when criticising the engineer on this matter it was as well to remember that he, in his turn, was endeavouring to meet the demands of users. These demands often made difficulty for the producers, but there was a certain amount of compensation in the fact that progress usually followed difficulty, and he thought it must be recognised as the joint duty of engineer and foundryman to endeavour to overcome such difficulties. He would strongly emphasise the importance of the utmost possible co-operation. The question of wear, continued Dr. Swift, was one which was exercising a good deal of attention at the Bradford Technical College, and it was a difficult one in which they were making certain inquiries. He thought perhaps there was a tendency at present to make rather too sweeping statements about improvements likely to be effected by adding this or adding that to mixtures. Sometimes a soft iron was more resistant to wear than an iron of closer structure. Mere hardness alone was an uncertain criterion of resistance to abrasion or breakage. It had often been said that coarse graphite structure gave a weaker iron than fine structure, but the form and shape of the graphitic structure, one could well imagine, might make a difference. It seemed to him that to get down to the fundamental reason for the effect of differences in graphitic structure it should be necessary to look to the shape and form of the graphite rather than to the actual size.

Mr. Hall asked whether the authors could tell the meeting anything about soda ash in iron, of which a good deal was heard lately. His (Mr. Hall's) experience suggested that it would yield a weaker rather than stronger iron.

AUTHORS' REPLY.

Mr. Neath, replying on behalf of the authors, said Mr. Thornton's point as to different results from two irons of the same analysis and under the same casting conditions was one of much interest and would need much investigation to give an explanation. It might very likely be a matter of gases, but the question was how and why and when? In regard to the burning-away of firebars, this was merely a matter of oxidation. The whole of the carbon was graphitic. Then the iron oxidised by effect of the oxidising gases in the fire, both external and internal. On the actual life of the bar one got different results with different coals. Some engineers made use of a too-high-ash coal which may give a large amount of ash which stuck to the bars and encouraged destruction by taking away the air-cooling action.

Mr. Young's various points, said Mr. Neath, were interesting, but not such as to call for any particular reply. His point about a low manganese content in oxidised iron was interesting and, one believed, well recognised. Dr. Swift's point as to possibilities in an open-grained iron for strength was one on which they would all look forward with interest to results of his tests. Research into the question of grain size and strength had shown that an evenly-distributed graphite did tend to give a higher strength than a coarse graphite. The Germans, said Mr. Neath, had shown that if one could get an iron which has very evenly-divided graphite and had no combined carbon at all one could get some remarkable results.

In answer to Mr. Hall, Mr. Neath said soda ash was not new but had been prominent lately. It tended to take the sulphur up into the slag, and if carried out under proper conditions it could be used with success. At the same time, it was liable to have an influence on composition which might result in a weaker iron rather than a stronger. It was claimed that the bubbling action clears the metal and was of benefit in that way. Beyond that he (Mr. Neath) did not feel he should attempt to commit himself.

A hearty vote of thanks was accorded Messrs. Neath and Poole for their Paper, on the motion of Mr. R. D. Welford, seconded by Mr. S. W. Wise (Hon. Secretary).

Early in the morning of May 24 one of the tar tanks in the Lion Foundry, Kirkintilloch, caught alight, and in a short time the flames spread to the other tanks in the shed, and also set fire to some wooden erections. The works fire brigade acted promptly, and with a generous supply of sand succeeded in subduing the conflagration, which at one time threatened to be serious.

Steel Castings.

Mr. Kirby's Paper* on intricate steel castings for automobiles gave rise to a considerable discussion of real practical interest. It was opened by MR. D. SHARPE, who said that probably some of their ironfoundry members would be interested to know that most of the castings which had been referred to and illustrated by the lecturer were made in green sand. There was one point upon which he thought more information would be useful and that was in connection with the statement that certain castings could be run more successfully from the bottom than the top. He understood that a casting with a very fine bore or screw end should be run from that end, but in regard to flanges being run up or down, he would like to know the reasons for deciding the one or the other.

Top Running Favoured.

MR. KIRBY replied that he used to be a believer in running a casting from the bottom, but he had now changed his ideas. When running from the bottom there was always a chance of a draw; there was a gradual dulling of the metal as it ascended in the mould, and when at last the mould was filled, the metal in the riser or feeding head might not be sufficiently hot to permit of proper feeding. Running from the top ensured that the top metal was always hot and fresh. Perhaps the advantage of running from the bottom was that there was a gradual pushing out of the gases, but with fairly open sand there was little danger of trapping gases even with top running.

Flaming Dressings.

MR. J. LONGDEN said that in regard to the reference to the dressing of the mould with oil or the flaming dressing, as it had been called, he would like to know what oil Mr. Kirby used. He had himself used such a dressing and found it very advantageous in certain types of iron castings. He had especially found it highly beneficial in the vicinity of the runner. It was interesting to know from Mr. Kirby that it was good practice. In regard to the use of chills, he noticed in one of the photographs which had been shown what was obviously a lot of nails; what kind of nails did Mr. Kirby use, and how did he arrive at the correct quantity to put in?

MR. KIRBY, in reply to Mr. Longden, said that he used Spermolin as a facing. In regard to the photograph mentioned by Mr. Longden, the nails were specially tinned and were of a special shape. In some castings he used twice or thrice as many as in the one shown. In some castings it was impossible to use a feeder, and he found the nails better than an external chill.

Nails as Chills.

MR. BALLANTINE said that he was very interested in the use of chills. He used nails, but found if the section was heavy they nipped at the neck and rose in the mould. He would be interested to know whether Mr. Kirby had found that to happen in steel.

MR. KIRBY replied that in the case of iron the metal was liquid for a longer time than steel. The nails would not rise in steel.

MR. D. SHARPE suggested that the nails would melt rather than rise through the steel.

A MEMBER stated that he had experienced cases where the nails had been found covered with metal.

MR. J. CURRIE said that what happened to the nails all depended on the section of the metal. In the case of wheel centres the nails could be seen floating around in the metal. He also thought that whether the chill melted also depended on the section of the metal. He noted that Mr. Kirby advocated the drying of all sands, and then adjusting to a known water content. He thought that was a good practice. He did not agree with Mr. Kirby about the bottom-pouring ladle giving metal absolutely free from slag. He would be very interested to see the wheels Mr. Kirby made in the rough with the gates. In regard to the practice of spraying the mould with oil, he thought it would be satisfactory for dry-sand work, but he would like Mr. Kirby to say definitely if he advised spraying for green-sand moulds instead of reinforcing. What kind of chaplets did Mr. Kirby use—stud or perforated?

Moisture in Sand.

MR. KIRBY said that as it was important not to over-chill in certain bosses he used spikes ¼ in. to ⅜ in. He was glad Mr. Currie agreed that it was advisable to dry the sand and add a definite amount of water. The practice had very definite advantages over the haphazard watering of the sand by each moulder. In regard to the question of freedom from slag, he meant the slag on top of the steel, but it was quite possible to get slag in the mould from the erosion of the stopper. In green sand they were bound to reinforce with nails, and spraying did not replace reinforcement. In regard to chaplets, he used both studs and perforated sheet metal. Regarding the melting of the chaplets, they would only melt in the middle, as the top and bottom were in the sand. Referring to castings such as the one exhibited, having very heavy and very light sections adjoining, and cast on webs which were afterwards cut away, he said that such castings could only be prevented from tearing by using brackets, especially in green-sand work. There were many instances where it was impossible to get a feeder head, and then they had to resort to chilling.

Machining Troubles.

A MEMBER asked Mr. Kirby if when using heavy external chills in series he found any trouble between the chills in the machining.

MR. KIRBY, in reply, said that there was no trouble unless the chills were not cleaned properly, when they had blow-holes as a result.

MR. WATSON said he was a great believer in running all moulds from the bottom. Mr. Kirby's argument about the continual supplies of fresh hot metal was quite good, but he preferred to get the same result by having additional runners part of the way up.

MR. KIRBY, in reply, said that Mr. Watson was probably connected with a foundry making very heavy castings, but in the case of castings between ½ cwt. and 1¼ cwts. it was not possible to put a runner halfway up.

A MEMBER asked if in inserting the nails they were put right into the head. He believed in putting them in right to the head, as if they were left protruding they melted. Did Mr. Kirby paint or prepare the chills in any special way?

MR. KIRBY said the distance the nails were put in depended upon the thickness of the metal. There was no special preparation of the chills, nothing but a little oil. External chills were just buffed to take away the scale.

MR. A. M. WILSON said that he regarded Mr. Kirby's remarks about running from the top as a challenge to the ironfounder, who had always been led to believe that running from the bottom was the correct practice, because of the freedom from disturbance. The retention of heat at the top of the metal was important, and his way was to build up an ingate at rather a lower level than necessary and stopping pouring when that ingate was fairly filled, and then changing over and pouring hot metal in the top gate, and in this way he kept the heat at the top as well as pouring from the top of the mould.

MR. KIRBY, in reply, said that the mere fact of changing the running from the bottom to the head proved that the top running was the correct way. There was no reason why the mould should not be run the whole way from the top. If the mould was properly reinforced there was no fear of tearing away the sand.

MR. D. SHARPE said that as the originator of the question of up or down running he would like to mention that it was in some places a common practice to use a branch runner—one branch being under the feeder head. He had used them where the down runner has both a bottom and a top ingate.

MR. KIRBY said that the branch runners might be satisfactory, but it was not worth the trouble of making if there was no need for them. The value of top running was that it reduced the amount of discard.

Vote of Thanks.

The CHAIRMAN (Mr. H. D. Campbell) said that they had listened to an exceedingly interesting Paper and had enjoyed a good discussion. His own experience in regard to steel was limited to one foundry when he was in America, and there the whole of the casting was done from bottom-pouring ladles. He thanked Mr. Kirby on behalf of the branch for the excellent Paper and hoped that he might pursue the subject further at some future time. The Paper that day showed the wisdom of having meetings in Edinburgh, as Mr. Kirby could get to Edinburgh easier than to Glasgow. It was a long and tiresome journey to Glasgow, but he felt sure that Mr. Kirby's enthusiasm would be a great benefit to the East of Scotland section and he hoped it would be the means of bringing in a number of new members.

MR. KIRBY, in thanking the President for the vote of thanks, said that he had enjoyed the meeting and he certainly would do his best to assist the Branch in general, and the Edinburgh section in particular.

* FOUNDRY TRADE JOURNAL, May 11, 1933, page 337.

Ferro-Chromium Freed from Import Duty.

By the Import Duties (Exemptions) (No. 5) Order, 1933, dated May 18, ferro-chromium is placed on the free list, as from May 23, in pursuance of a recommendation by the Import Duties Advisory Committee. The Committee's Report and the Order are contained in a White Paper (Cmd. 4330) published by H.M. Stationery Office.

It is pointed out that ferro-chromium is an essential constituent of certain alloy steels and is of great importance to the Sheffield special steel industry. It is made in the electric furnace, and production has hitherto been confined to countries possessing abundant sources of cheap hydro-electric power. The possibility of its production in this country by the use of coal-electric power is being actively explored, but there is no likelihood of production in the near future on a scale sufficient to meet requirements. The existing duty on imported ferro-chromium places the British special-steel makers at a disadvantage in the export markets. The Committee accordingly recommend that it should be removed.

The Import Duties (Drawback) (No. 4) Order, 1933, approves a scheme for allowance of drawback on castings and sheets of V4A welding quality stainless steel contained in exported top-dyeing machines for the dyeing of combed wool.

Future Supplies of Scrap.—In the 10th Henry Marion Howe Memorial lecture before the annual meeting of the American Institute of Mining and Metallurgical Engineers, in New York, recently, DR. G. B. WATERHOUSE, after reviewing steel-making processes, said that one of the main factors in the growth of the basic open-hearth process is the use of scrap, which at present is the cheapest raw material in the industry. Accurate figures compiled in the census of 1929 showed that 29½ million tons of scrap with an estimated value of 450 million dollars were used in steelmaking. Some 750 million tons of steel are estimated to be in use to-day in the United States, which indicates a great potential supply of scrap for many years to come.

XUM

Estimating Metal Stocks.

(From a Correspondent.)

While it may be perfectly true that with the values of metals down to record low levels losses are not so serious on a monetary basis as they were when prices stood high, yet it is essential that a careful check should be kept upon the tonnage passing through the factory. To this end it is usual to maintain records of the theoretical holding throughout the working year, in order that, without the delay occasioned by stopping production to facilitate weighing up, accurate figures may always be available. Every manufacturer will please himself as to the amount of detail required for purposes of accountancy, but in essence any scheme of this nature must be based upon ascertained figures to begin with, adjusted at stipulated intervals in accordance with the receipts and despatches.

In addition to a grand total of metal held, divided under such broad headings as copper, tin, nickel, etc., from which it is possible to estimate in conjunction with other details the tonnage at risk, it is usually necessary to have information about the weight of raw material, viz., ingots, slabs, scrap, etc., available for the foundry, in order that supplies may be maintained through intelligent anticipation of future requirements. The extent of the stock thus held will vary according to the policy of purchasing, but from a production viewpoint it is obviously essential that reserves should not be allowed to decline below a certain level. Should consignment stocks be held, these will, of course, be carefully segregated, and a separate record maintained. Too much stress cannot be laid upon the importance of accurate stock records in the raw material warehouses for at a time like the present when the uncertainty of the price trend is compelling metal manufacturers to buy very warily, serious trouble may arise if supplies are not forthcoming promptly for the execution of rush orders. Fortunately for the manufacturer, fairly adequate stocks of all the base metals, with the possible exception of high-grade zinc, are available in this country, and the holding of raw materials may, therefore, be allowed to decline to low proportions without undue risk.

In other sections of the factory it will be necessary to know what weight of castings are on hand, the tonnage and composition of the holding of material in process and the make-up of the stock of finished goods. During the course of a year a certain amount of sectional weighing may be done, and, of course, in the ordinary way of factory routine weights are being taken and recorded every day. At this point it is opportune to stress the importance of adequate supervision of all weighing, the need for accurate and up-to-date machines, with a strong plea in parentheses that weighbridges should, whenever possible, be under cover. Money expended on keeping all weight-recording apparatus, whether beam scales, platform machines or any other type, in perfect working order is well spent, and to this end a painstaking and competent inspection at stated intervals is essential. This check may be undertaken by a qualified member of the engineering staff or an annual contract may be fixed up with an outside firm. Instances of serious losses through inaccurate weighing are by no means unknown, and it must be borne in mind that it is not only at the points of receipt and despatch that these may be incurred, for faulty heat weighing may result in over-addition of high-priced constituents in alloys. If estimation of metal stocks means anything at all, it certainly includes the principle of absolute accuracy in the determination of weights.

In the course of the manufacturing process all metals are subject to loss, some of which is recoverable and some absolute, the extent varying with the nature of the metal involved. Aluminium, virgin or remelted, in its usual foundry form of notched bars, may be stored for a considerable period without trouble, but scrap, and especially light turnings, deteriorate very much through exposure to the atmosphere and should therefore be worked up promptly after receipt. Zinc is a very volatile metal, and even when worked alone, as in galvanising, serious losses occur through volatilisation from the bath, which inevitably provides a large surface for oxidation. In brass-making the high temperatures required to deal with the copper make for higher losses in zinc, and careful estimation of this is necessary if serious discrepancies between actual and theoretical stocks at the end of an accounting period are to be avoided. Experience will determine just what allowance must be made in respect of the different metals in use, and also to what extent the loss is absolute or recoverable by a subsequent process. It is not suggested that the physical stocktaking is going to disclose a tonnage in complete agreement with the book figures, but unless due attention is paid to the factor error created by manufacturing losses, and furthermore the fact that very few virgin metals are 100 per cent. metal, the discrepancy is likely to be wide enough to provide a source of serious disappointment.

From time to time it is possible to take an "eye stock," or in other words to go round the factory on a tour of weight-estimation. This is not a job for an inexperienced inspector to tackle, for without expert knowledge of sizing-up metals in bulk a result very wide of the mark may be reached. From this there naturally arrives doubt as to the accuracy of the theoretical or book figures and much uneasiness is caused. Stacks of metal in the form of slabs, cakes or ingots may be estimated without very much trouble, for the material is standing in a manner which lends itself readily to a count if the stacking has been done methodically. Rods, tubes and sections in varying lengths are difficult to deal with accurately and all material in process is hard to sum up as it is usually very scattered. The cubic measurements of a pile of sheets are quickly taken, but such a stack is far from solid, for even the modern stretching machine does not take all the "belly" out of rolled metal. All things considered it is probably wiser to instal a stock-estimation system as near foolproof as possible, and having done so to rest content until the time comes when a physical stocktaking confirms or disproves its accuracy.

Notes from I.B.F. Branches.

Middlesbrough.—At the annual general meeting of the Branch, held on April 7, which was presided over by Mr. S. P. Thorpe, the retiring President, the following officers were elected for 1933-34:—*Branch President*, Mr. J. E. Mercer; *Senior Vice-President*, Mr. J. Hackwood; *Junior Vice-President*, Mr. H. E. Wooley; *Honorary Secretary*, Mr. F. A. Harper; *Honorary Financial Secretary*, Mr. T. E. Bashford; *new Councillors*, Mr. J. Gould and Mr. J. Charlton.

The meeting concluded with a very interesting description of the work of the Technical Committee by Mr. N. D. Ridsdale and Mr. J. E. Mercer, the former illustrating his remarks with a quantity of sand-testing apparatus.

The L.M.S. Railway have decided to make extensive trials with new-type motor rail-coaches using heavy-oil fuel. The coaches are designed for branch-line work where passenger traffic is light, but where an increase in the frequency of the train service is regarded as desirable in view of motor-coach competition. Six new units have been ordered. Three, to be built by Leyland Motors, Limited, will be fired by heavy-oil engines. The other three, to be supplied by the Sentinel Waggon Works, Limited, will utilise steam boilers fired with heavy-oil fuel.

Process for Producing High-Quality Large Castings of Aluminium Light Alloys.

By W. Claus.

In the first part of the article the attempts which have been made to solve the problem of producing large castings of high quality are discussed in the light of their theoretical background. These have devolved into three main groups, concentrating the problem respectively on alloy compositions, on the design of moulds and on the material of moulds. A survey of the principal research indicates that gas inclusions and porousness can never be entirely overcome by attention solely to the alloy properties and to the mould design. The solution of the problem may therefore lie in the direction of the mould material. Examination of fundamental considerations shows that rapid cooling, that is to say, the provision of good-conducting mould material, conduces to the closest packing of the crystal structure, and hence to the highest mechanical properties. Without due consideration of this essential principle, all the effort expended along the lines of producing good casting alloys and working out suitable design is in vain. The author therefore carried out investigations into the different available methods of producing the most rapid crystallisation possible. He investigated first the possibilities of supercooled sand moulds, but found them unpromising. He then worked on chills constructed of different materials, and built up in different manners, and in this direction he reports very encouraging results from:—(1) The use of metallic sands with or without addition materials; (2) the use of moulds—solid, designed to meet special thermic requirements, cooled, etc.—whose melt-contact surfaces are formed of good-conducting material finely powdered or ground; and (3) the use of moulds whose melt-contact surfaces are faced with sheet (or wholly or partially of geometrically fitting elements which, put together, give plane walls), while the bulk of the mould is constructed either of good or bad-conducting material (lead or zinc, etc., or sand or lime, etc.), it being immaterial which.—"Light Metal Research" abstract.

Clyde holds its Place in Shipbuilding.—"We must adopt a 1933 mentality, and, by planning ahead, studying the trends and grasping the opportunities as each arises, we can and must resume our place in the van of British industrial progress," said Sir A. Steven Bilsland, Bart., to West of Scotland business men last week, when, as President, he gave his review of the trade situation at the quarterly meeting of the Glasgow Chamber of Commerce.

The next six months would be a period of the greatest importance, with the World Conference as the major event, he said. Recovery would be slow, but it would gradually open up a new stage in world development. Governments could only prepare the way. They, the business men, must set out on it. The West of Scotland had not been slow on such occasions in the past. It had the leadership, the enterprise and the skill to progress again.

The most recent review of the geographical distribution of production was much less unfavourable to this area than the complaint they heard of the "drift to the south" would lead them to expect. With regard to shipbuilding, merchant ships under construction in Britain showed an increase over the preceding month for the first time for three years. It was gratifying to record the fact that the Clyde had not only held, but rather improved, its relative position among the shipbuilding centres of Britain.

So long as shipping and shipbuilding were subsidised, as they were in many countries abroad, the outlook must remain uncertain for these industries here. The industrial position remained practically as it was, although internal trade in Great Britain was more hopeful, and it was noteworthy that the recent results of many of the smaller companies throughout the country showed considerable improvement.

First Report of the Steel Castings Research Committee.

By a Committee of the Iron and Steel Industrial Research Council.

[*Abstract.*]

(*Continued from page* 362.)

Examination of Typical Castings.

A sound casting is one which is substantially free from cavities and cracks of any kind. The importance of several features affecting soundness will now be considered in more detail by following the history of modifications in methods of casting adopted in overcoming difficulties encountered in typical instances of the manufacture of cast-steel hydraulic cylinders and engine columns.

Hydraulic Cylinders for Cranes.—Sixteen cylinders were required, namely, 8 slewing, 4 topping and 4 lifting cylinders. The approximate dimensions of the cylinders are shown in Figs. 5 and 7. The lifting cylinders were twice as long as the slewing cylinders but had fewer and simpler lugs and feet. The steel was required to comply with the following tests:—Ultimate tensile strength: 28 to 35 tons per sq. in.; elongation: not less than 15 per cent., and bend test: a bar 1 in. by 1 in. bent over a radius not greater than 1⅛ in., angle not less than 60 deg. for upper limit of tensile strength 90 deg. for lower limit, and varying in proportion to strength between these limits.

Finally each casting was subjected to a water pressure of 3,000 lb. per sq. in.

The cylinders were cast in acid open-hearth steel in a mould arranged in a pit with the axis of the cylinder at an angle of about 15 deg. to the horizontal, the gland end being uppermost. The arrangement, which is shown in Fig. 1, was used for all cylinders, with the exception that in the long cylinders about four feeders from the main runner were used instead of the two shown in the sketch. The causes of rejection are given in Table I. The first of these rejections, a slewing cylinder which failed under water pressure at 3,000 lb. per sq. in. by leaking at the side rod brackets, and subsequently showed evidence of fine cracks at the corresponding position on the inside surface, was examined in detail. The defective portion of this casting which was selected for examination is shown in Fig. 11. Typical radiographs showed extensive irregular cracks, mostly circumferential, and indications of cavities near the change of section in the wall. The thicker portion of the cylinder in this vicinity was also penetrated, but showed no serious flaws. Just above the side rod bracket where the leak occurred under hydraulic pressure, an extensive series of fine transverse cracks was revealed (Fig. 12). At a position further removed from the side rod bracket the radiographs gave some indication of longitudinal cracks, and nearer the boss the course of an unsuspected longitudinal crack was very distinctly shown (Fig. 13).

The material of the casting had the chemical composition:—C, 0.28; Si, 0.29; Mn, 0.58; S, 0.048, and P, 0.052 per cent. It had not been sufficiently annealed. The first longitudinal cut made closed up, the movement indicating the existence of residual internal stress, compression at the outside and tension at the inside. The microstructure was acicular (Fig. 14) and the mechanical tests, though sufficient to meet the specification requirements, were not as good as they should have been (Table II). The notched-bar impact figure was poor.

The macrostructure of numerous longitudinal and transverse sections of the casting was examined by sulphur printing and by etching with copper ammonium chloride solution, and the results are summarised in Figs. 2 to 4.

Along the whole length of the longitudinal slice, etching revealed the presence of dendritic crystals arranged perpendicularly to the surface. The transverse slices showed that this dendritic growth did not extend round the whole circumference, but occurred at the outer surface in one quadrant and at the inner surface at the opposite quadrant. In the intervening space the crystals were equiaxial and smaller. It seems clear that the metal, rising steadily in the mould, began to solidify at the surface at which the dendrites are situated. Dendritic growth would proceed, the temperature of the metal continuing to fall until conditions were such that free growth of the crystals from nuclei formed in the liquid could take place. The solidification of this liquid would not be complete until after the mould had been filled and would be accompanied by considerable movement to compensate for contraction. On the assumption that feeding occurred in the direction of the point of the V-segregates, it was found that the feet of the casting had been fed from the cylinder wall and so also had the side bracket beyond which the leak occurred. The opposite side bracket showed no similar macrostructure but contained a cavity.

The structure of the longitudinal slice, extending for about 2 ft. from the top of the casting, indicated that the direction of feeding had been downwards throughout. The reserve of metal came from the upper feeding head and not from the lateral runner. Apparently, however, solidification of the middle section of this length supervened before feeding of the lower section was complete, causing considerable contraction stresses in the neighbourhood of the slope or change in section. The indications of the macrostructure in this region are therefore that more efficient feeding is required at a lower level.

The most serious and possibly the only fatal defect in this casting was the presence of cracks. These were both transverse and longitudinal. The longitudinal cracks may have been caused by the contraction of the walls of the casting on to a too-rigid core (Fig. 15). The transverse cracking is to be attributed to contraction stresses intensified by inadequate feeding. The cracks

TABLE I.—*Number and Cause of Rejections of Hydraulic Cylinders for Cranes.*

Method of Casting.	Slewing (8).*		Topping (4).		Lifting (4).	
	Accepted.	Rejected.	Accepted.	Rejected.	Accepted.	Rejected.
Horizontal (no chills)	3	5	1	3	3	1
Horizontal (with additional feeder, chills, etc.)	3	2	3	0	—	—
Vertical (gland end down)	—	—	—	—	0	1
Vertical (gland end up)	—	—	—	—	1	0
Total	6	7	4	3	4	2

Order of manufacture.	If rejected, nature of defect.
	Slewing Cylinders.
	Cast nearly horizontal, no chills.
2	Accepted.
4	Leaking at side rod brackets; evidence of fine cracks inside (examined in Research Department, Woolwich).
7	Accepted after welding defects in gland.
8	Leaking at side rod brackets and at anchor arm. Fine cracks in neck ring coinciding with leaky areas at side rod brackets.
12	Leaking at side rod brackets, fine cracks inside neck ring coinciding with this area.
14	Accepted after welding defects in neck ring, gland and air-cock boss.
15	Leaking at side rod brackets and at anchor arm, fine cracks on one side in neck ring.
16	Crack developed in neck ring after water test at 3,000 lbs. per sq. in.
	Cast nearly horizontal, with additional feeder, chills, etc.
18	Failed on water test; crack developed 7¾ in. long near anchor arm.
19	Cylinder burst at 2,600 lbs. per sq. in. (Cylinders 18 and 19 replaced by forgings.)
21, 23, 24	Accepted.
	Topping Cylinders.
	Cast nearly horizontal, no chills.
5	Accepted.
6	Leaking at side rod bracket, fine cracks at this position inside neck ring.
11	Leaking at gland end where foot joins body.
13	Crack developed in neck ring after water test.
	Cast nearly horizontal, with additional feeder, chills, etc.
17, 20, 22	Accepted.
	Lifting Cylinders.
	Cast nearly horizontal, no chills.
1	Accepted after welding defect at pressure inlet.
3	Accepted after welding defects in gland and neck ring.
9	Accepted.
10	Failed in water test.
	Cast vertically, gland end down, thickness of cylinder wall increased to 2¼ in.
25	Transverse crack, 9 in. × 1 in. deep, behind right side bracket. Blowholes in neck ring (examined in Research Department, Woolwich).
	Cast vertically, gland end up.
26	Accepted.

* Two replaced by forgings.

TABLE II.—*Mechanical Properties of Hydraulic Cylinder Casting No.* 4.

Tensile Test. (0.564-in. dia., 2-in. acting length)

Limit of proportionality	7 tons per sq. in.
Yield point (0.2 per cent. permanent set)	11.0 „ „
Maximum load	27.8 „ „
Elongation on 2 in.	16 per cent.
Reduction of area	16 „

Izod Impact Test (B.S.I. standard test-piece).

Energy absorbed to fracture — Average 5.5 ft.-lbs.

were frequently localised by interdendritic segregation (Figs. 16 and 17). The segregated regions would probably act as surfaces of weakness at a high temperature.

Reasons for Failure.

The following points arising from the examination of this cylinder may be emphasised:—(1) The line of transverse defects in the vicinity of the change of section of the wall, and the probability that feeding the full length of the portion examined was effective only from the top, suggests the advisability of increased feeding at a lower level; (2) there was serious longitudinal weakness, not disclosed by the hydraulic test; and (3) the casting had received inadequate annealing. The spread of a crack, under stress, would be more likely to occur in such a casting than in one which had been fully annealed. Conclusions (2) and (3) are of importance in the light of the failure of castings Nos. 18 and 19.

Modified Methods of Manufacture.

Meanwhile replace cylinders had been made by the same method with the following modifications:—(1) The change of wall thickness at the gland end was tapered more gently; (2) steel chills, 2 in. thick and 2½ in. wide, were secured in the core at positions where the anchor arm or the side-rod brackets join the cylinder (that is, where the leaking occurred in the defective cylinders) and at the beginning of the change of section; and (3) an additional feeder from the main runner was introduced to feed the upper (gland) end.

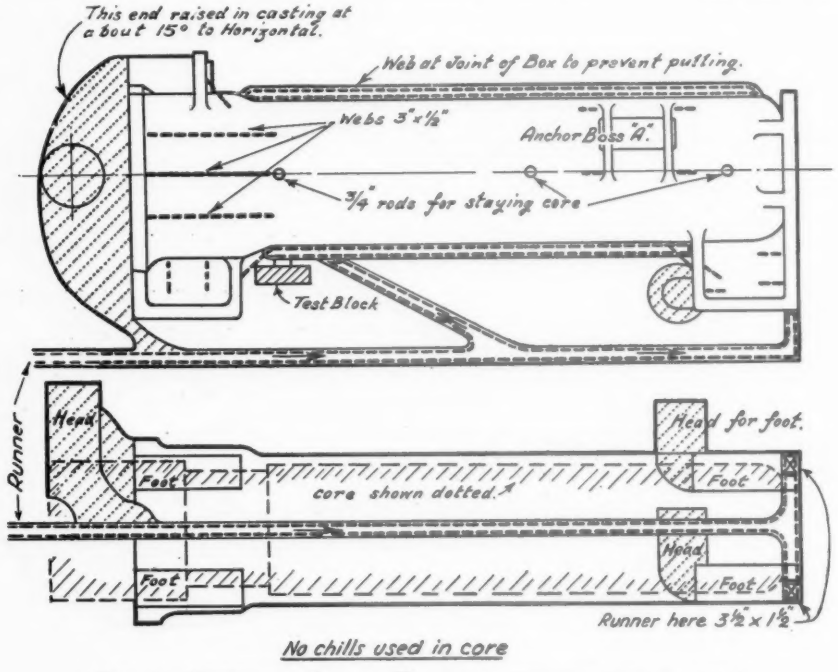

Fig. 1.—Method of Casting Hydraulic Cylinder (not to scale).

These modifications had the effect of overcoming the porosity which caused the rejection of the earlier cylinders, and the results illustrate the advantages to be derived from a judicious use of chills; but the use of chills apparently intensified, or at least did not reduce, the seriousness of the longitudinal defect observed in the cylinder examined. Two failures occurred under water pressure in these replace cylinders, both accompanied by longitudinal cracking (Figs. 5 and 6). The extensive cracking produced by water pressure in cylinder No. 19 suggests that the steel was brittle and that the cylinder had not been efficiently annealed. No material was obtained for examination from these cylinders.

The two slewing cylinders thus outstanding were replaced by forgings. The remaining lifting cylinder was cast vertically with the gland end down, while at the same time the wall thickness was increased to 2¼ in. (Fig. 7).

A large head was provided at the top, and small heads on the various brackets and lugs. The casting was fed by a single runner with 11 subsidiary branches feeding the cylinder walls, and a double branch feeding the gland end through the two feet. The core was built up on a perforated steel tube wound with 1½ in. of plaited straw, coated with a layer of powdered silica and fireclay. This was followed by a thick layer of composite loam built up round iron rods and suitably coated and baked. The steel used was a medium-carbon steel made by the acid open-hearth process, and the casting was annealed by heating to 900 deg. C. during 24 hrs., holding at 900 to 950 deg. C. for 8½ hrs. and cooling in the furnace during 52 hrs. with the furnace dampers in. The cylinder showed a serious transverse crack at the bottom end of the casting, and was not put forward for the water test.

Three pieces were selected for examination, namely, the top or closed end, a piece adjacent to the gland end and containing the two side lugs, and the gland end itself. A thorough examination showed that the top closed end was free from defects and that the intermediate section was sound except for a small hole at the back of one of the lugs.

The gland end contained a number of defects. The chief of these was a transverse crack about 8 in. long and 1 in. deep in places, immediately above one of the side-rod brackets. In addition there were about fifty rounded cavities showing inside the cylinder on the machined surface. They were distributed over a length of 14 in. and appeared all round the circumference. The cavities had the form of blow-holes, and were oxidised on their inner surface, indicating that they may have been intensified and modified in form by gas from the core or mould. Their surface was, however, not deeply decarburised (Fig. 18), suggesting that the steel had been in contact with only a limited amount of oxidising gas, probably entrapped air. Their position near the bottom of the casting and their oxidised surface make it improbable that the gas was derived from the steel.

Radiological examination revealed no additional defects, and it seems probable that the only important crack in the casting was the long one which caused rejection.

The chemical composition and average mechanical properties of test-pieces cut from the top and bottom of the castings are recorded in Table III, and the microstructure (Fig. 19) shows that the casting had been adequately annealed.

Table III.—*Average Composition and Mechanical Properties at Top and Bottom of Lifting Cylinder Casting No. 25.*

	Top.	Bottom.
Chemical Composition.		
Carbon, per cent	0.32	0.38
Silicon, „	0.32	0.39
Manganese, „	0.68	0.71
Sulphur, „	0.030	0.035
Phosphorus, „	0.040	0.040
Tensile Tests.		
Limit of proportionality. Tons per sq. in.	12	13
Yield point. (0.2 per cent. permanent set). Tons per sq. in. ..	15	16
Maximum load. Tons per sq. in. ..	32.0	35.5
Elongation on 2 in., per cent. ..	26	17
Reduction of area, per cent. ..	34	18
Izod Impact Test. (B.S.I. standard test-piece.)		
Energy absorbed to fracture. Ft-lbs.	11	9

Dangerous circumferential stress, such as had caused longitudinal cracking in Nos. 18 and 19, had been eliminated in this casting by attention to the design of the core. The provision of remedies against longitudinal stress was a matter of greater difficulty. The projecting brackets and lugs had the effect of anchoring the casting in the sand mould at different positions, and the concentration of stress at the root of one of the lugs would explain the occurrence of the crack at that position. It seems probable, however, that insufficient feeding of the gland end contributed towards the formation of the crack. This, combined with the effect of entrapped air, caused the formation of cavities, some few of which, under the influence of the longitudinal stresses set up by the contraction of the casting in the mould, developed into a network of cracks following areas of interdendritic segregation (Figs. 20 and 21). Those cracks were usually small, but had in one region at least spread to such dimensions as to constitute a serious defect.

The whole of the casting, except a 3-ft. length at the bottom, had been very efficiently fed by the system of side runners. The method of casting the gland end down rendered it impossible to place adequate heads on the heavy section, and this arrangement (combined with the fact that within 3 ft. of the end only two runners were employed, both at the bottom) resulted in inadequate feeding of the gland end of the casting.

It appears, therefore, that this casting—in many respects of excellent quality—was rendered defective by inadequate feeding of the gland end, a conclusion confirmed by the fact that a casting subsequently made with the gland end, which comprises the heaviest and most intricate section, uppermost, but without any other important modifications of the mould, was free from obvious defects and successfully withstood the 3,000 lb. per sq. in. hydraulic test specified for these cylinders.

Engine Column Castings.

The castings referred to formed one leg of the complete composite engine column. The steel was required to comply with the same mechanical tests as that used for the hydraulic cylinders. These single-leg columns were cast in the manner indicated in the diagram (Fig. 8). The main defect from which they suffered was the presence of transverse cracks in the pad of metal at *C* (Fig. 8). The steel employed was acid open-hearth steel, containing about 0.35 per cent. of carbon and 0.7 per cent. of manganese. The sulphur content was normal (0.04 per cent. maximum), but the phosphorus was slightly higher, varying from 0.048 to 0.065 per cent. in different casts.

The variations in casting practice which are shown in Table IV came under observation.

Several of the castings which showed defects were withdrawn for examination before they had been annealed.

They all showed a satisfactory macrostructure and were comparatively free from major segregation and from shrinkage cavities. They had all been efficiently fed. An undesirable feature in the microstructure of several of the castings was the presence, at right angles to the cooling surface, of continuous threads of ferrite rich in phosphorus and containing minute non-metallic inclusions (Fig. 22). The evidence suggests that cracks are initiated in and probably facilitated by the presence of such regions as well as by interdendritic segregation generally (Fig. 23). Some improvement in this respect might be achieved by the use of steel with lower sulphur and phosphorus contents, though none of the steels examined was in any way abnormal in chemical composition.

The important defects in all these castings were cracks due to contraction stresses, localised at certain positions by the design of the castings. Provision against these defects of normal contraction had not been adequate to prevent the formation of cracks. The measures taken at different times to remedy this defect have been indicated in Table IV.

In some castings a head was placed over the thick pad of metal, but this did not serve to eliminate the tendency to crack; in fact, all castings made with a thickened pad or a head at this position cracked transversely, the crack starting from the inside.

The effect of running from the wide end instead of from the narrow end was tried. Assuming that the region of smallest cross-section would cool fastest, and that for equal cross-sectional areas the metal furthest removed from the runner would be coldest, then running from the narrow end would tend to uniformity of temperature of metal throughout, and to simultaneous solidification from both ends, giving rise to cumulative contraction stresses at the central thick pad. Running from the wide end would ensure that solidification started at the narrow end; and if the bulk of the central pad of metal was at the same time reduced, it should enable solidification to proceed uniformly from narrow end to wide end. It was thus probable that wedge action of the core would be less likely to arise. On the other hand, however, the straining action of the sloping surface of the mould would, on the same argument, be greater. Actually, it was found that simple transference of the runner from the narrow to the wide end did not effect the necessary improvement in the central transverse cracks, though it appeared to reduce the liability to corner cracks.

Chills and, later, brackets were used to strengthen the region of the thick metal pad. While it is not desired to detract from the value of the use of properly-designed chills, it must be recorded that in the only casting examined in which they had been employed, their action promoted too rapid solidification of the chilled area. This had the effect of producing, beyond the border of the chilled region, a segregated area in which longitudinal stresses readily caused cracking. The defect which the chill was intended to eliminate was, thus, only displaced.

When tear brackets were employed the brackets themselves were in some cases the site of small cracks. These are shown in the radiograph, Fig. 24 (page 384). When the brackets were machined away and the surface ground and etched, it was seen that these cracks occur immediately beyond the coarsening of the structure due to the thick metal of the ribs, Fig. 25, and show some relation to the orientation of the dendrites. Attempts to correlate this cracking with the dimensions of the brackets in relation to the wall thickness of the casting and also with the shape of the bracket were unsuccessful.

Small internal brackets at the corners of the box section proved effective in finally eliminating corner cracking. The successful remedial measures finally adopted included running from the wide end, which together with rapid easing greatly reduced the corner cracks, and strengthening of the central pad of metal with long internal brackets and the corners with small internal brackets.

TABLE IV.—*Variations in Method of Casting Engine Columns.*

Method of Casting (see Fig. 8).	Results.
1. Run at *A*	Transverse cracks under pad; corner cracks.
2. Run at *A*; head on pad	Transverse cracks under pad; corner cracks.
3. Run at *B*	Transverse cracks under pad; fewer corner cracks.
4. Run at *A*; brackets on pad	Longitudinal crack in joint of mould, corner cracks; V-cracks at end of brackets.
5. Run at *A*; chill on pad	Transverse cracks beyond chilled region.
6. Run at *B*; brackets on pad	Transverse crack at base of end flange due to omission of necessary bracket, and two V-cracks at ends of brackets; otherwise successful.
7. Run at *B*; reduced thickness of pad, special precautions to release mould quickly at the narrow end.	Successful.

NOTE.—In methods 4 to 7, tear brackets were also provided across the corners.

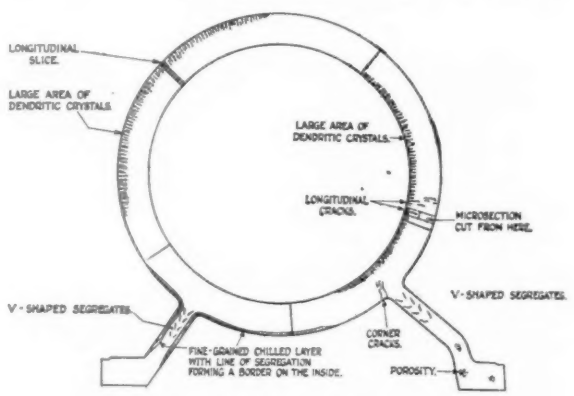

FIG. 2.—TRANSVERSE SECTION OF HYDRAULIC CYLINDER CASTING, ABOUT 16 IN. FROM TOP END AS CAST. (For method of casting, see Fig. 1.)

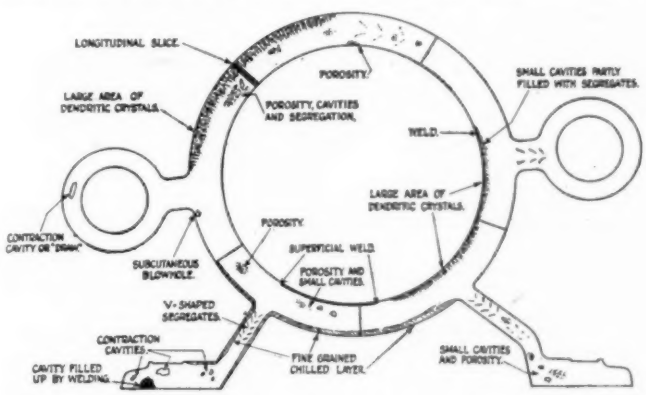

FIG. 3.—TRANSVERSE SECTION OF HYDRAULIC CYLINDER CASTING, ABOUT 7 IN. FROM TOP END AS CAST.

Critical Examination of Castings made under Controlled Conditions.

The castings described above and the various other castings examined up to this stage were all made in the course of ordinary manufacture.

TABLE V.—*Chemical Composition of the Castings, Casting Temperature, and Time Taken to Fill the Mould.*

N.d. = not determined. Correction for optical pyrometer sighted on stream of steel (C. Johns, *Transactions of the Faraday Society*, 1918, vol. 13).

obs. temp.	1,400 deg.	1,500 deg.	1,600 deg. C.
correction.	+ 143 deg.	+ 151 deg.	+ 169 deg. C.

Casting— No	Casting— R.D. Mark	Type of steel.	Composition. C per cent.	Si per cent.	Mn per cent.	S per cent.	P per cent.	Ni per cent.	Cr per cent.	Casting Temperature (Corrected). Deg C.	Time taken to fill mould. Sec.	Illustration. Fig. No.
1	*JFN*	Basic electric ..	0.19	0.12	0.76	0.026	0.021	0.56	0.11	1,592	27	32
2	*JFO*	(Same cast) ..	0.19	0.10	0.76	0.028	0.024	0.56	0.11	1,586	25	33
3	*JFP*	(Same cast) ..	0.17	0.10	0.76	0.024	0.023	0.56	0.13	1,580	28	36
4	*JGC*	Basic electric ..	0.24	0.32	0.93	0.028	0.021	0.37	0.12	1,592	47	34
5	*JGD*	Acid open-hearth	0.22	0.24	0.95	0.033	0.034	0.16	0.06	1,557	39	
6	*JJL*	Acid open-hearth	0.16	0.32	1.09	0.024	0.034	0.09	0.07	—	—	35
7	*JJM*	Acid open-hearth	0.31	0.34	0.97	0.024	0.034	0.03	0.02	—	—	
8	*JNY*	Basic electric ..	0.27	0.41	0.59	0.008	0.008	0.15	0.05	—	14	
9	*JNZ*	(Same cast) ..	0.26	0.40	0.60	0.008	0.008	0.18	0.05	—	14	10
10	*JVZ*	Basic electric ..	0.27	0.39	0.67	0.003	0.021	N.d.	N.d.	—	—	
11	*JWA*	(Same cast) ..	0.27	0.38	0.67	0.003	0.022	N.d.	N.d.	—	—	37
12	*JWB*	(Same cast) ..	0.28	0.38	0.67	0.002	0.021	0.08	0.02	—	—	
13	*KLX*	Basic electric ..	0.24	0.31	1.08	0.026	0.019	N.d.	N.d.	1,627	40	38
14	*KLY*	(Same cast) ..	0.25	0.31	1.10	0.020	0.019	0.27	0.08	1,627	50	—
15	*KLZ*	Basic electric ..	0.26	0.37	1.03	0.016	0.014	0.18	0.09	1,663	37	39
16	*KMF*	Basic electric ..	0.24	0.24	0.97	0.015	0.024	0.05	0.07	1,610	30	40

The designs of the hydraulic cylinder and engine column castings appeared to present exceptional

difficulty from the foundry point of view. The examination of experimental castings made under conditions defined as fully as possible, and closely controlled, appeared likely to add considerably to the knowledge gained as to the characteristics, causes and remedies for the main types of defects.

A casting was chosen weighing about 2½ cwts. and offering some features which sometimes cause difficulty. This was a "branch-piece casting for auxiliary steam"; a drawing of the casting is shown in Fig. 9.

The design was submitted to a number of practical steel-foundry managers of different works for their opinion, and nine replies (marked A to J) were received to the following questions:—(1) What proposals would you put forward for modifying the details to obviate any special difficulties? (2) Assuming that the original design is maintained, what would you consider to be the best way of making up the pattern and the mould, and what arrangements would be adopted for running and feeding the casting? and (3) How would these details of manufacture be modified if the alteration of design proposed under (1) were accepted?

The replies may be summarised as follow:—

1.—(i) One works, D, declined to attempt to manufacture the casting as one piece, but suggested casting in two pieces.

(ii) Another works (J) would not undertake to make it as a hollow casting of this design, but only as a solid casting, subsequently bored out.

(iii) C, D, F and H suggested a reduction of thickness of the metal section at *CC* (Fig. 9).

(iv) E suggested that the lightening holes in the ribs should be larger.

(v) E suggested increasing the thickness of the ½-in. ribs to ⅝ in.

(vi) B suggested inserting ⅝-in. ribs under the flanges of the branches.

(vii) C suggested moving the centres of the branches to the centre line of cylinder.

(viii) A suggested the omission of the bulkhead flange and end flange.

(ix) C suggested ribs between the bulkhead and end flanges.

To the modifications (ii) to (vi) there would be no objection on the part of the user, but (vii) to (ix) could not be allowed, though omission of the bulkhead flange from the casting as proposed in (viii) followed by welding-on a flange at this position might have proved to be an advantage, since considerable trouble was experienced in this region of the casting. The proposal in (i) might also have been permitted, but was thought to involve too great a departure from the manufacturing conditions of the other experimental castings to be included in the trial.

2.—All agreed that the mould should be made up in two halves with the joint as much as possible along the longitudinal centre line of the casting. Opinions varied as to the best way of making up the core. One firm (J) held the definite opinion that the most economical way to make this casting was to cast solid, with suitable cores for the branches, and to bore out the central hole. Though it was realised that this was a method of evading, rather than overcoming, the difficulties inherent in the production of the casting, some branch pieces were cast in this way and subjected to examination with the others.

A variety of positions for casting were suggested:—A, B, C, D, F and H: Horizontal or slightly inclined with the 2-branch side uppermost; G: horizontal with the 2-branch side at the bottom, and E and J: vertical with the end containing the branches uppermost and that containing the bulkhead flange at the bottom.

It was generally proposed to place heads on the top of all flanges in castings made horizontally, but the heads proposed varied considerably in dimensions; that suggested for the bulkhead flange, for example, varied from 3 × 1 in. to 6 in. in dia.

For the position of the runners, the following were suggested:—C: At the centre of the casting; H: at the rib in the bulkhead flange;

Table VI.—*Experimental Castings; Casting Conditions and Some Results of Examination.*

Average weight of finished casting, 2 cwts. 2 qrs. 7 lbs.

No.	Position of casting in mould. H. = Horizontal. V. = Vertical.	Position of runner. L. = Longitudinal. T. = Transverse to axis of casting.	Number of risers.	Percentage of metal cast in finished casting.	Total area of gates. Sq. in.	Soundness. N. = Normal.	Cracks.	Surface quality.
1	H. 2-branch side at bottom	L. Bottom of No. 14 flange	6	70	24	Below N. Large cavities due to shrinkage and blowing	Slight. At ends of three of the bulkhead brackets	Patches due to blowing.
2	H. 2-branch side at top	L. Bottom of No. 1 flange	7	68	23	Below N. Fairly large shrinkage cavities mainly in thick sections	Slight. Do.	Mainly good.
3	V. Bulkhead end at bottom	T. Periphery of No. 14 flange	4 (1 long with 5 branches)	63	31	Below N. Shrinkage cavities large in thick sections, small in thin sections	Slight. Do.	Mainly good.
4	H. 3-branch side at top	T. Bottom of bulkhead flange	7	45	84	Sound, except for a few small cavities	Serious circumferential crack at bulkhead flange	Very good.
5	H. Do.	Do.	7	46	81	Sound	Do.	Very good.
6	H. 2-branch side at top	T. Periphery of No. 1 flange	7	56	41	Normal. Small cavities near top of mould	Slight. At ends of one of bulkhead brackets	Internal blowing near bulkhead flange.
7	H. Do.	Do.	7	59	50	Normal. Cavities near bulkhead flange	No cracks	A few patches of internal blowing.
8	H. 3-branch side at top	T. Between bulkhead and No. 14 flanges	9	44	60	Sound, except for pinholes below bore surface	No cracks ..	Internal areas of pin-hole blowing, mainly in upper part of casting.
9	H. Do.	T. Do.	9	44	60	Do.	No cracks ..	
10	V. Bulkhead end at bottom	L. Middle of end face of No. 14 flange	3	37	71		No cracks ..	Fair number of surface laps and folds with isolated shallow blowing.
11	V. Do.	L. Do.	3	37	71		No cracks ..	
12	V. Do.	L. Do.	3	37	71		No cracks ..	
13	H. 3-branch side at top	L. Bottom of No. 1 flange	7	44	80	Normal. Some central unsoundness in walls	Serious circumferential cracks at junction of body and No. 1 flange and slight longitudinal crack in bore	
14	H. Do.	L. Do.	7	49	56	Do.	Serious circumferential cracks at junction of body and No. 1 flange	
15	H. Do.	T. Periphery of No. 1 flange	7	50	54	Do.	Slight longitudinal crack in bore	Good. Small local areas of internal blowing.
16	H. Do.	T. Do.	8	54	74	Normal. Some small cavities uniformly distributed	Slight. At ends of two of the bulkhead brackets	Good. Slight internal and external blowing.

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FIG. 12.—CIRCUMFERENTIAL DIRECTION. RADIOGRAPH AT POSITION ABOVE SIDE ROD BRACKET WHERE LEAKAGE OCCURRED IN PRESSURE TEST, SHOWING FINE TRANSVERSE CRACKS.

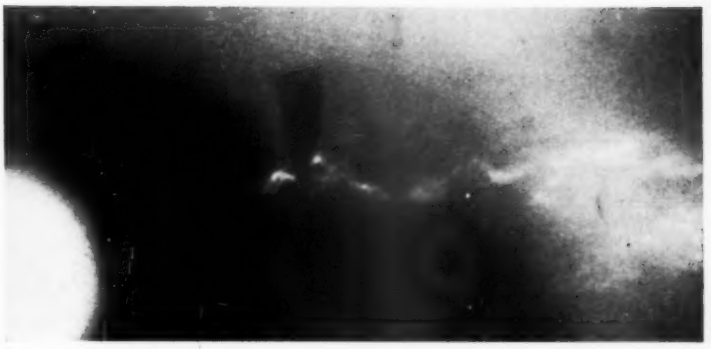


FIG. 13.—LONGITUDINAL DIRECTION. RADIOGRAPH AT POSITION FURTHER REMOVED FROM SIDE ROD BRACKET, SHOWING LONGITUDINAL CRACKS.

FIG. 14.—ACICULAR STRUCTURE, INDICATING INADEQUATE ANNEALING. ETCHED WITH 5 PER CENT. NITRIC ACID IN ALCOHOL. × 100.

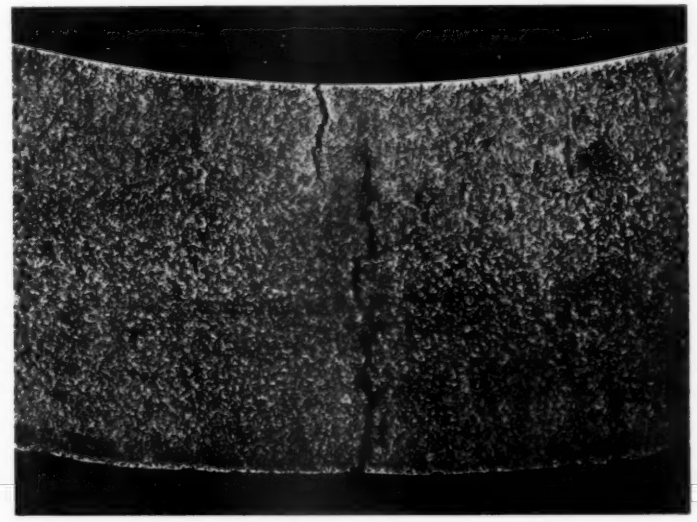
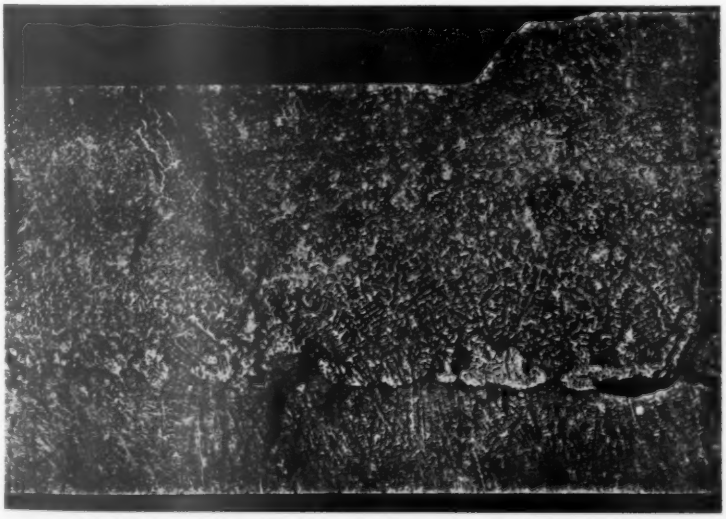
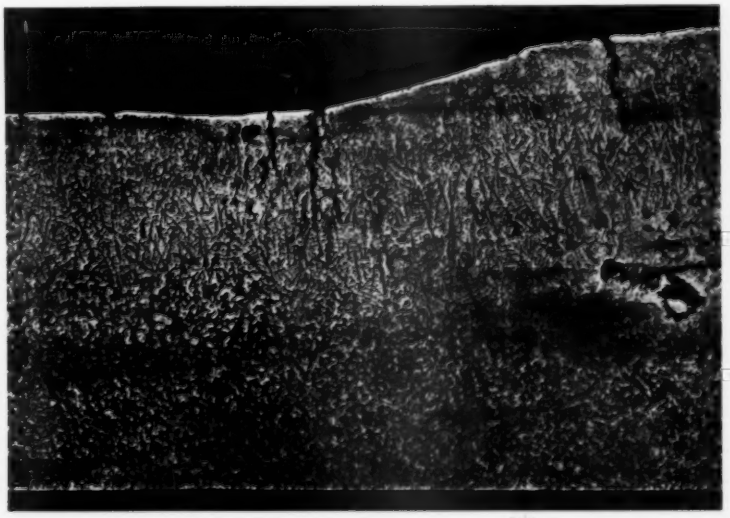


FIG. 15.—TRANSVERSE SECTION, SHOWING LONGITUDINAL CRACK. ETCHED WITH COPPER AMMONIUM CHLORIDE SOLUTION. × 1.

FIG. 14A.—CRACK FOLLOWING THREAD-LIKE SEGREGATE. ETCHED WITH STEAD'S REAGENT. × 25.

FIGS. 14 AND 15.—CAST-STEEL HYDRAULIC CYLINDER, NO. 4.





FIGS. 16 AND 17.—LONGITUDINAL SECTIONS FROM THE REGION WHICH SHOWED LEAKAGE. ETCHED WITH COPPER AMMONIUM CHLORIDE SOLUTION. × 1.

XUM

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(Continued).

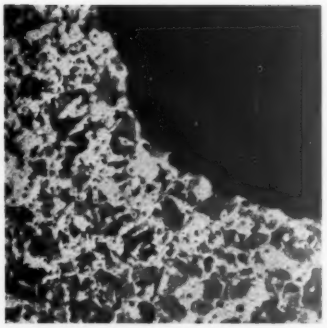

Fig. 18.—Absence of Decarburisation Round Cavities. × 25.

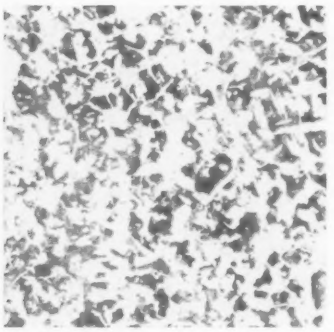

Fig. 19.—General Structure. × 25.

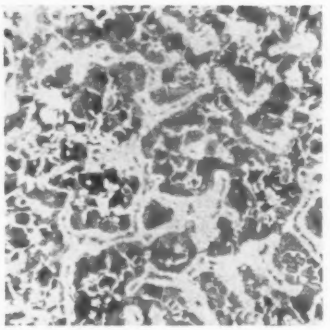

Fig. 20.—Inclusions in Ferrite. × 25.

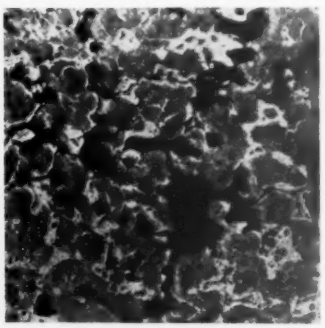

Fig. 21.—Cracks extending from Cavities along Segregated Intermediate Areas. × 25.

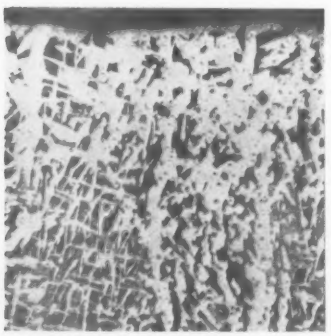

Fig. 22.—Structure at Surface. × 15.

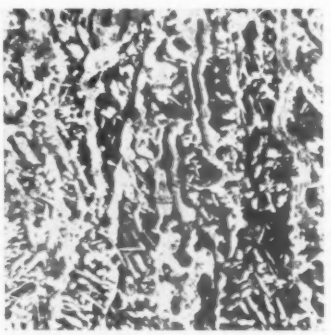

Fig. 23.—Cracks passing along Ferrite Threads. × 15.

Figs. 18 to 23.—Etched with 5 per cent. Nitric Acid in Alcohol.

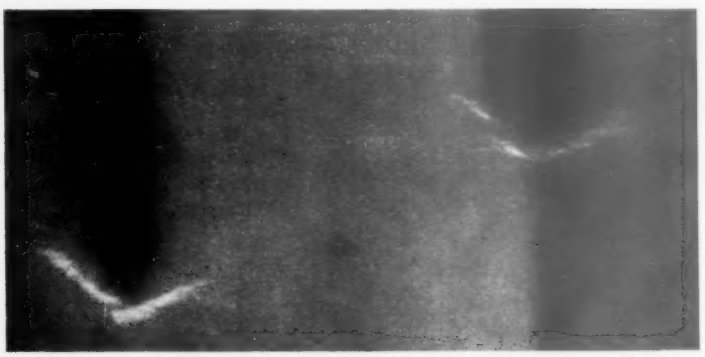

Fig. 24.—Radiograph, showing V-Cracks at Ends of Brackets.

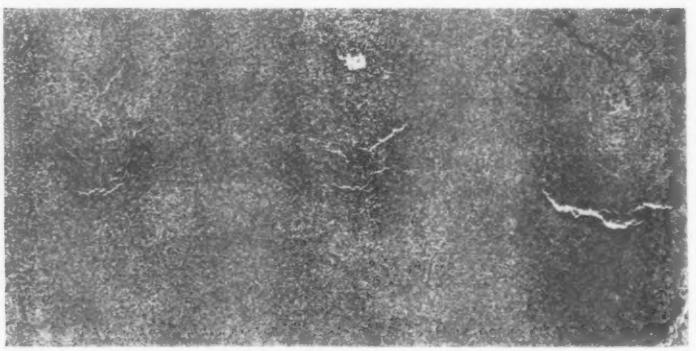

Fig. 25.—Ink Print of Section of Steel beneath Brackets, showing Macrostructure and V-Cracks. Etched with Copper Ammonium Chloride Solution.

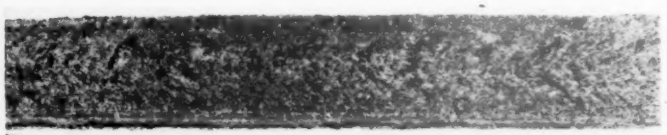

Fig. 26.—Sulphur Print of Section through Wall of Casting No. 14, opposite Large Flange on 3-Branch Side.

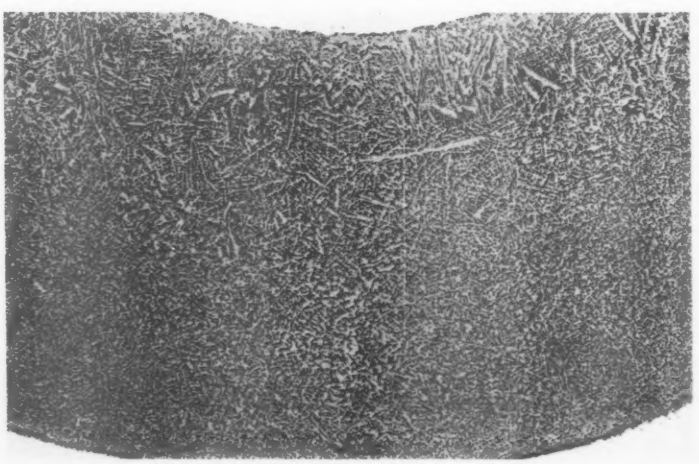

Fig. 27 (Right).—Ink Print of Section through End Flange at which Casting No. 6 was run.

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(Continued).

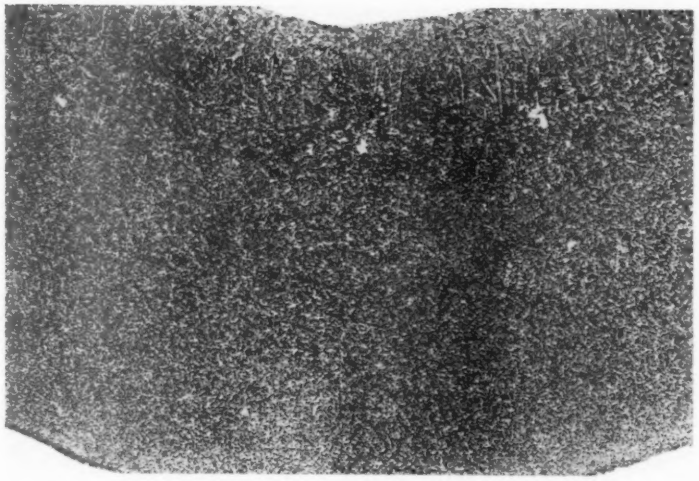

FIG. 28.—INK PRINT OF SECTION THROUGH FLANGE AT OPPOSITE END OF CASTING NO. 6.

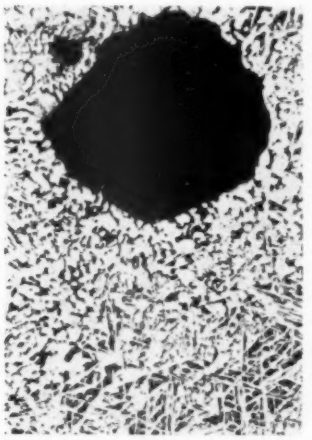

FIG. 29.—CASTING NO. 1. ABSENCE OF DECARBURISATION ROUND CAVITY. × 15.

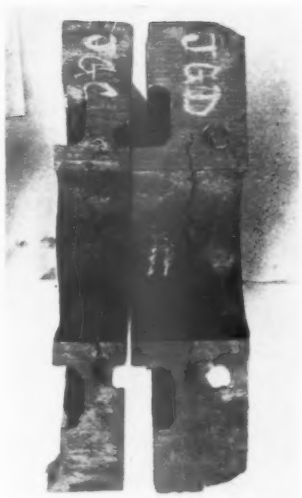

FIG. 30.—CASTINGS NOS. 4 AND 5. CIRCUMFERENTIAL CRACKS BENEATH BULKHEAD FLANGE.

FIG. 31.—SECTIONS THROUGH HEADS OF EXPERIMENTAL CASTINGS NOS. 1, 2, 4 AND 5.

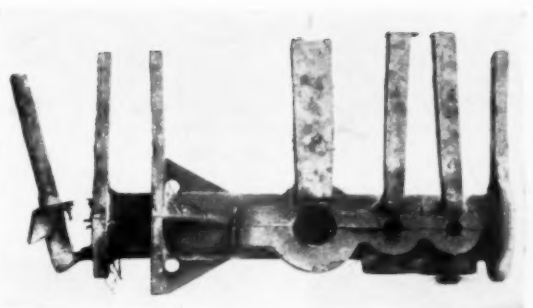

FIG. 32.—CASTING NO. 1.

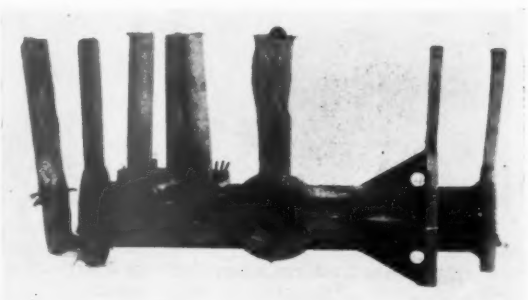

FIG. 33.—CASTING NO. 2.

FIG. 34.—CASTING NO. 4. TYPICAL OF NO. 5 ALSO.

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(Continued).

Fig. 35.—Casting No. 6. Typical of No. 7 also.

Fig. 38.—Casting No. 13. No. 14 was similar, but with Smaller Heads.

Fig. 36.—Casting No. 3.

Fig. 37.—Casting No. 10. Typical of Nos. 11 and 12 also.

Fig. 39.—Casting No. 15.

Fig. 40.—Casting No. 16.

Fig. 41.

Fig. 42.

Figs. 41 and 42.—Transverse Radial Sections, showing Defects at Junction of Wall and Flange. Etched with 3 per cent. Aqueous Solution of Ammonium Persulphate. × ⅓ approx.

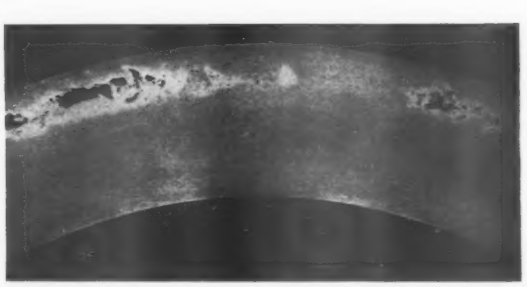

Fig. 43.—Section through Wall and Flange, showing Decarburised Area surrounding Cavities. Etched with 3 per cent. Aqueous Solution of Ammonium Persulphate. × ⅓ approx.

B and F: at the flange at the end nearest the branches, and E, G, and J: at the flange at the end removed from the branches.

3.—For modifications 1 (iii) to 1 (vi), the changes would be slight. For modification 1 (i) it was proposed to cast the part containing the bulkhead flange horizontally, and the part containing the branches vertically.

The preliminary inquiry thus revealed a wide divergence of opinion as to the way in which the casting could best be made. Sixteen castings have been made, embodying many of these proposals, by British and Continental makers. Certain suggestions—for instance, the proposal to make the casting in two parts and the proposal to place the runner at the centre of the casting—were not actually tried. The first of these, though probably good practice, was considered to be not sufficiently comparable with the other methods, and the second was not proceeded with on account of the high degree of probability (revealed by trouble with the bulkhead flange) that it would lead to transverse cracking in the middle of the casting.

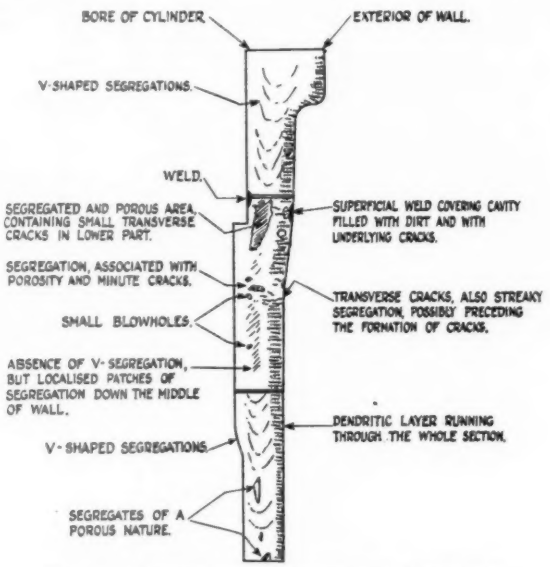
BORE OF CYLINDER.
EXTERIOR OF WALL.
V-SHAPED SEGREGATIONS.
WELD.
SEGREGATED AND POROUS AREA CONTAINING SMALL TRANSVERSE CRACKS IN LOWER PART.
SUPERFICIAL WELD COVERING CAVITY FILLED WITH DIRT AND WITH UNDERLYING CRACKS.
SEGREGATION, ASSOCIATED WITH POROSITY AND MINUTE CRACKS.
TRANSVERSE CRACKS, ALSO STREAKY SEGREGATION, POSSIBLY PRECEDING THE FORMATION OF CRACKS.
SMALL BLOWHOLES.
ABSENCE OF V-SEGREGATION, BUT LOCALISED PATCHES OF SEGREGATION DOWN THE MIDDLE OF WALL.
DENDRITIC LAYER RUNNING THROUGH THE WHOLE SECTION.
V-SHAPED SEGREGATIONS.
SEGREGATES OF A POROUS NATURE.

FIG. 4.—LONGITUDINAL SECTION OF HYDRAULIC CYLINDER CASTING. TOTAL LENGTH ABOUT 2 FT.; POSITION SHOWN IN FIGS. 2 AND 3.

The castings (with four exceptions) were received as they came from the mould with heads still in place, and without annealing. Particulars of the conditions of casting were obtained in as complete a form as possible.

The examination carried out in the Research Department, Woolwich, consisted of a determination of the weight of the castings before and after removal of the heads, the areas of the heads at their most constricted part, the chemical analysis at two positions, transverse and longitudinal sectioning and macro-examination of the castings at eight positions, radiographic examination of certain areas, and mechanical tests at four or more positions before and after annealing.

Table V gives the chemical analysis and method of manufacture of the steel, the rate of pouring and casting temperature. The general results of the examination are summarised in Table VI along with a statement of the principal conditions of casting.

Results of Metallurgical Examination.

Macrostructure.—The macrostructure rarely showed segregation. There was a marked absence of V-segregates in the wall, suggesting that the heads had been suitably spaced for efficient feeding. The only noticeable instances of the occurrence of V-segregates were in:—Casting No. 2—indicating inadequate feeding of 3-branch side, and Castings Nos. 13, 14 and 15—indicating movement of metal towards the thick pad of metal on the 3-branch side. (Fig. 26.)

The dendritic structure was generally more highly developed in the flange at which the casting was run than at the end remote from the runner (Figs. 27 and 28).

There was marked columnar growth of crystals in the walls of castings Nos. 4, 5, 6, 10 and 12; but a comparison with castings showing a smaller crystalline formation failed to distinguish any effect of this structure on the mechanical properties in the cast or annealed condition.

Microstructure.—The microstructures were of two types, namely:—Acicular ferrite and pearlite: Nos. 1, 2, 3, 7, 10 and 16, and dendritic structure of ferrite and pearlite: Nos. 4, 5, 6, 13, 14 and 15. The dendritic structure persisted after annealing, and appeared at higher power as an incomplete pearlite network enclosing grains of ferrite.

Contraction Cavities.

The character of the castings in this respect is indicated under the heading "Soundness" in Table VI. The cavities were free from segregation and showed no decarburisation at the surface (Fig. 29).

Cracks.—Three types of cracks were found, as indicated in Table VI, namely:—(1) Small cracks at the ends of the bulkhead brackets; (2) occasional longitudinal cracks running radially from the bore, and (3) large circumferential cracks in or near flanges.

The first type has already been described. There was no essential difference in the dimensions and design of any of the brackets, but the fact that cracking occurred at two or three brackets in the same casting or at none appears to indicate that the formation of cracks was not fortuitous, but depended on some casting condition, which, however, could not be identified. Longitudinal cracks on the inner surface, but not penetrating the wall, were present in Nos. 13 and 15 only. There was no reason to suppose that the cores were more rigid in these instances.

Examples of the third type of crack were found in four castings, Nos. 4, 5, 13 and 14. In Nos. 4 and 5 almost complete circumferential cracks were present in the bulkhead flange at which these two castings were run (Fig. 30). The origin of the cracks would therefore seem to be the heating effect of the runner delaying the solidification of a thick section, which thus becomes subjected to contractional stresses while still hot. In the other castings, Nos. 13 and 14, similar cracks appeared in the radius of the junction of the wall with the end flange at which they were run.

Mechanical Properties.—Mechanical tests were made on all castings before and after annealing.

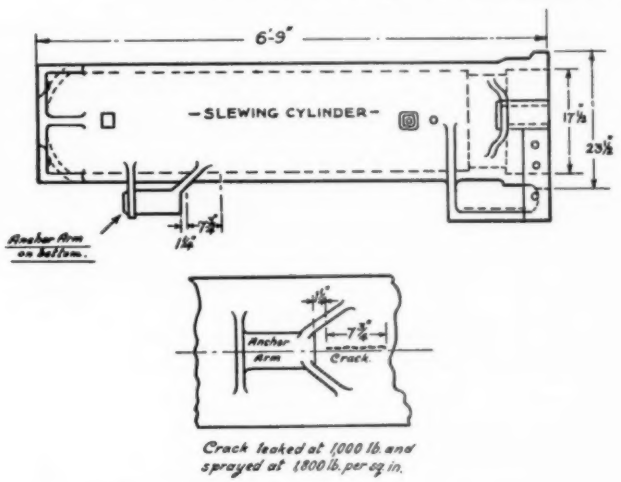

FIG. 5.—POSITION OF CRACK IN SLEWING CYLINDER NO. 18 (NOT TO SCALE).

The results given in Table VII are the averages of a number of tests from each cast of steel. All the annealed steels would pass the 90 deg. bend test usually specified. Tests on the steels annealed for 1 hr. at 945 deg. C. and cooled in the furnace at the rate of about 10 deg. per min. vary in a regular manner according to the composition of the steel. The tests on the steel as cast showed a less regular change with composition, but are also given to indicate the usual improvement brought about by annealing.

A double annealing (heating at 950 to 1,000 deg. C. and a second heating at 750 to 800 deg. C.) followed by a rate of cooling equal to that employed in the single annealing, gave mechanical properties very similar to those obtained after a single annealing.

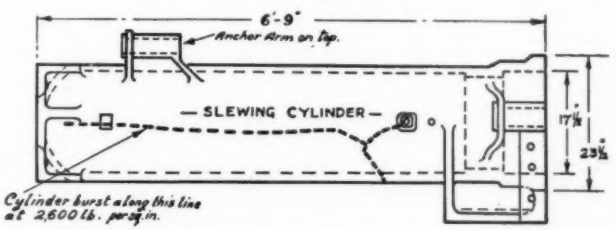

FIG. 6.—POSITION OF CRACK IN SLEWING CYLINDER NO. 19 (NOT TO SCALE).

Annealing followed by cooling at a very slow rate gave inferior properties to those obtained after similar annealing followed by more rapid cooling in the furnace. Observed values after very slow cooling were reduced by the following approximate amounts:—Elastic limit, yield point and maximum load, 2 tons per sq. in.; elongation, 2 per cent.; reduction of area, 6 per cent.; and Izod impact figure, 7 ft.-lbs.

A double annealing may be an advantage in a

large casting, but is unnecessary in small castings. Very slow cooling after annealing may be essential for large castings or smaller ones of complicated form, but if it must be adopted a definite deterioration in mechanical properties must be accepted.

Conclusions from Metallurgical Examination. Effect of Variations in Conditions of Casting.

Whilst none of the castings was perfect, it may be concluded that Nos. 1, 2 and 3 would certainly have been rejected for unsoundness; Nos. 4, 5, 13 and 14 would certainly have been rejected for cracks. The other castings might have been accepted; of these Nos. 10, 11 and 12 were cast solid and therefore must be considered separately.

Position of Casting in the Mould.—The remaining castings, Nos. 6, 7, 8, 9, 15 and 16, made from steels which differed considerably in composition and method of manufacture, were all cast horizontally. No. 6 and 7 with the 2-branch side up and the rest with the 3-branch side up. The method of casting horizontally with either the 2- or the 3-branch side uppermost facilitated the escape of gas from the mould as well as rendering accessible portions to be fed by risers. The casting (No. 1) made with the branches downwards showed a greater amount of internal surface blowing, and the vertical position (No. 3) appeared to introduce considerable difficulty in adequately feeding all parts.

Weight and Area of Heads.—The percentage of metal cast in the finished casting, and the total area of gates are given in Table VI, together with a summary of the conditions of the steel as regards soundness. The results are expressed in a diagram shown in Fig. 11, in which the vertical axis represents the percentage of metal in the finished casting, and the horizontal axis the area of the heads at their most constricted parts. The region representing suitable conditions in practice is marked out. The results indicated that a proportion of heads 44 per cent. by weight of the total metal cast (other conditions being satisfactory) produced reasonably sound castings, and that no great gain in soundness accrued from using percentages greater than 50 per cent., that is, with a weight of finished casting less than 50 per cent. of the total weight of metal cast. The lowest total area of gates found in conjunction with reasonable soundness was 41 sq. in., and there was no evidence of any appreciable influence of a further increase in area of gates independently of weight of heads.

Sections of typical heads indicated that narrow heads solidified in such a way as to give long discontinuous piping, while shorter heads of greater cross-section and weight showed themselves to be much more efficient and gave an extensive cavity near the top passing into a narrow pipe in the lower part (Fig. 31).

The spacing of the heads, as well as their size and shape in relation to the adjacent portion of the casting, exercises a considerable influence on the efficiency of feeding. In castings in which the heads were unevenly placed, evidence of the direction of flow of metal was apparent in the macrostructure, but the spacing had not been sufficiently wide to give rise to cavities in the walls.

Position of Runner.

Castings Nos. 4 and 5 showed almost complete circumferential cracks in the bulkhead flange at which they were run, while Nos. 8 and 9, cast similarly but run at the wall between the bulkhead flange and the end flange, showed no cracks. When the runner leads into a thick section in the middle of a casting, its heating effect delays solidification, which proceeds from the ends, and the central section is thus subjected while in a weak condition to tensile stresses due to contraction, an effect avoided when the metal is run into the narrower wall and the thicker sections are fed by heads. There are, however, serious objections to running direct into a narrow wall, and running at end flanges is to be preferred. Castings Nos. 13 and 14, made in this way, had, however, similar circumferential cracks in the radius of the junction of the wall with the end flange at which they were run, whilst Nos. 1 and 2, also run at the end flanges, showed no cracks.

The main differences in the conditions of manufacture of these two pairs of castings were that Nos. 13 and 14 were cast at a temperature 35 deg. to 40 deg. C. higher than Nos. 1 and 2, and were also cast more slowly. It is unlikely that the casting temperature of Nos. 4 and 5 could have exceeded that of Nos. 8 and 9 by a similar amount, but there was in this instance also a marked difference in the rate of pouring.

Rate of Filling the Mould.

If the castings are arranged in order of the time taken to fill the mould, other variables being for the moment neglected, the order is found to bear a close relation to the freedom from cracks (Table VIII). Although there were other factors varying in individual instances, which may have influenced the behaviour of the steel—notably the provision of brackets to prevent cracking in Nos. 15 and 16, and the position of the runner in Nos. 4 and 5 which would tend to promote cracking—the results indicate that the rate of filling the mould may have a pronounced effect in tending towards freedom from cracking, and point to the desirability of filling the mould as rapidly as possible, if necessary continuing to feed the heads as solidification occurs.

Casting Temperature.

With a favourable position in the mould and a proper distribution of heads, the variations

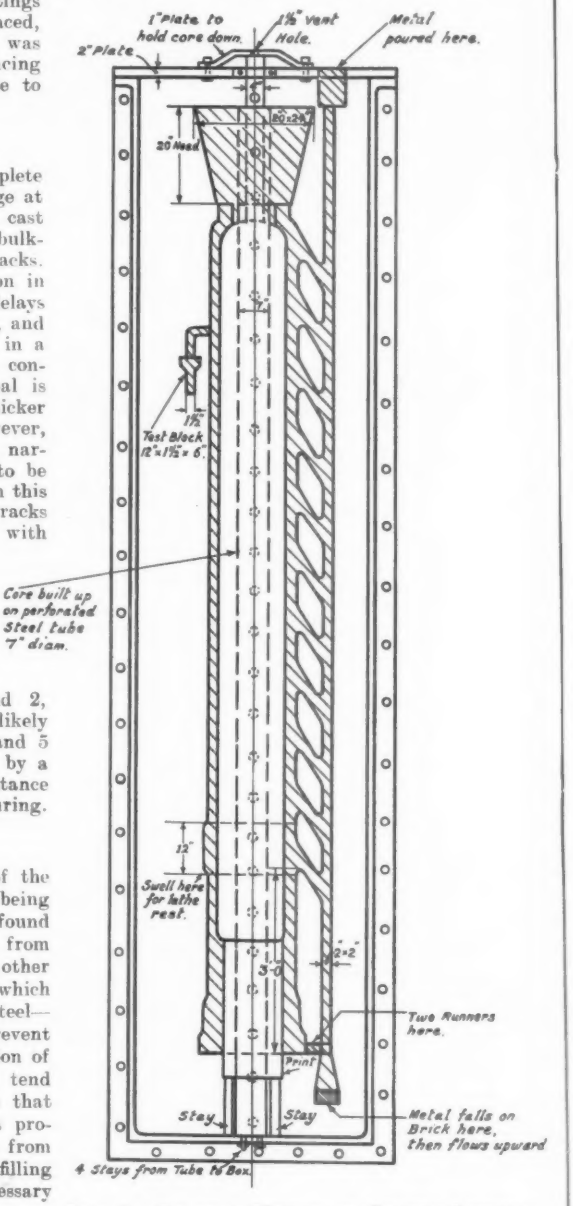

Fig. 7.—Vertical Method of Casting Lifting Cylinder (not to scale). The Core was supported on ¼-in. Stalk Chaplets, 8 at the bottom, 2 at each side, and 3 on top, before the Mould was placed in the Vertical Position.

Table VII.—*Mechanical Properties, as Cast and after Annealing at 945 deg. C.*

Casting No.	Composition. C per cent.	Si per cent.	Mn per cent.	Ni per cent.	Cr per cent.	Condition.	Limit of Proportionality. (Tons per sq. in.)	Yield point. (Tons per sq. in.)	Maximum load. (Tons per sq. in.)	Elongation on 2 in. Per cent.	Reduction of area. Per cene.	Izod impact figure ft.-lbs.
Basic electric steel.												
1, 2, 3	0.18	0.11	0.76	0.56	0.12	As cast ..	9	13.3	28.5	21	26	11
						Annealed	14	16.7	29.8	31	50	40
16	0.24	0.24	0.97	0.05	0.07	As cast ..	10	16.1	30.4	15	20	12
						Annealed	17	20.6	31.2	16	25	43
4	0.24	0.32	0.93	0.37	0.12	As cast ..	10	16.3	29.5	9	13	8
						Annealed	19	21.0	33.0	15	22	24
13, 14	0.24	0.31	1.09	0.27	0.08	As cast ..	10	16.6	32.8	16	21	6
						Annealed	20	22.5	35.3	23	31	34
15	0.26	0.37	1.03	0.18	0.09	As cast ..	10	17.4	32.5	11	12	6
						Annealed	20	23.6	36.8	23	36	40
Acid Open-Hearth Steel.												
6	0.16	0.32	1.09	0.09	0.07	As cast ..	11	13.6	29.7	29	45	10
						Annealed	14	16.0	29.5	30	61	37
5	0.22	0.24	0.95	0.16	0.06	As cast ..	9	13.1	29.8	21	28	7
						Annealed	14	16.8	31.6	31	48	32
7	0.31	0.34	0.97	0.03	0.02	As cast ..	11	14.8	33.9	21	27	4
						Annealed	15	17.2	35.6	21	31	14

Table VIII.—*Time Taken to Fill the Mould in Relation to Freedom from Cracks.*

Casting No.	Time taken to fill mould. Sec.	Cracks.
8	14	None.
9	14	
2	25	Slight, at ends of 3 of the bulkhead brackets.
1	27	
3	28	
16	30	Slight, at ends of 2 of the bulkhead brackets.
15	37	Slight longitudinal crack in bore.
5	39	Serious
13	40	
4	47	
14	50	

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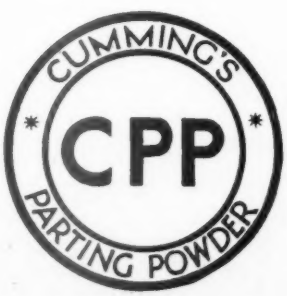

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in casting temperature recorded (1,557 deg. to 1,663 deg. C.) appeared to have little influence on the internal soundness, but a high casting temperature tended to increase the minute porosity at positions where crystal growth from different surfaces met. Apart from this, it had little effect on the mechanical properties in the cast condition, and none after annealing. There was no evidence in relation to the casting under discussion that reduced speed of pouring would compensate for the effect of high casting temperature. It thus appeared desirable to run these castings not only as quickly as possible but at a moderate or relatively low, as opposed to a high, casting temperature.

(To be continued.)

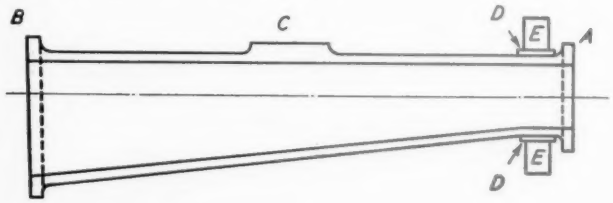

Fig. 8.—Engine Column Casting. *A*: Original position of runner, changed to *B*. *B*: Original position of head, changed to *A*. *C*: Extra metal and machining allowance. Trials were made with (*a*) a second head, (*b*) chills, and (*c*) brackets at *C*, also with oil-sand core at *D*, and an open space left at *E* for easing.

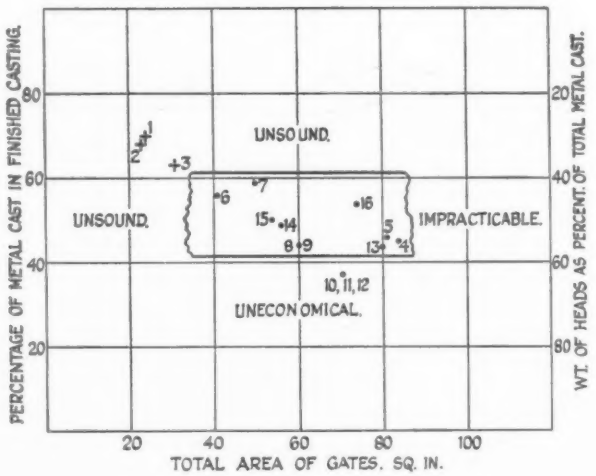

Fig. 11.—Experimental Casting. Relation between Weights of Heads, Areas of Gates and Soundness.

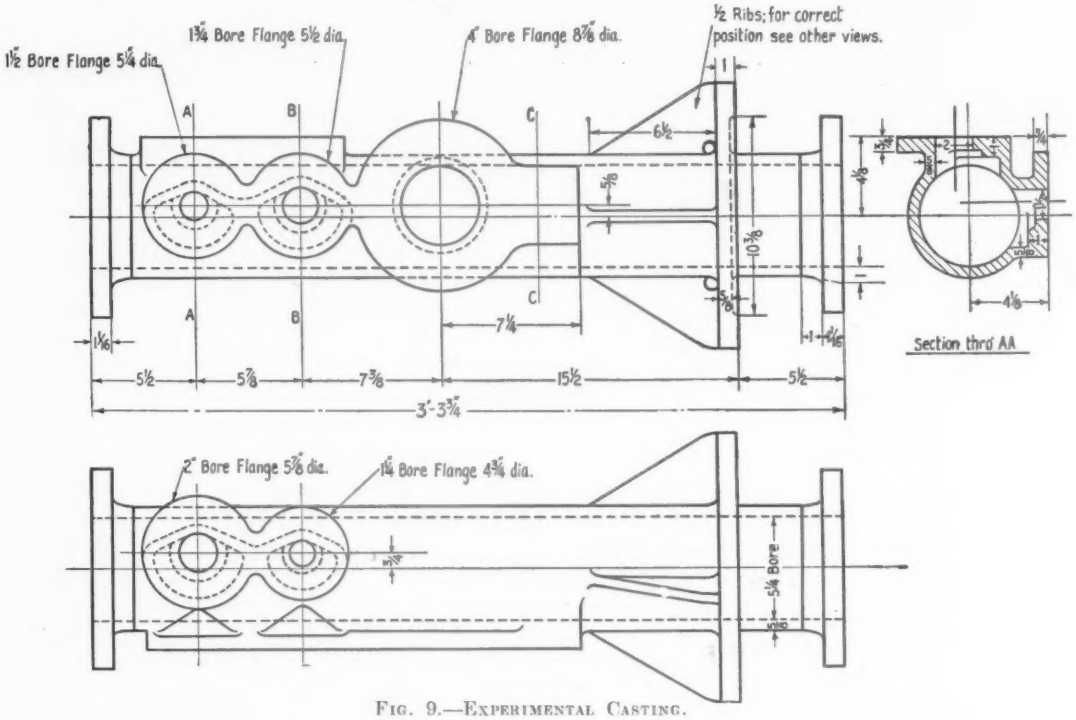
1¾" Bore Flange 5½ dia.
1½" Bore Flange 5¼ dia.
4" Bore Flange 8⅞ dia.
½ Ribs; for correct position see other views.
Section thro' AA
2" Bore Flange 5⅞ dia.
1¼" Bore Flange 4¾ dia.
3'-3¾"

Fig. 9.—Experimental Casting.

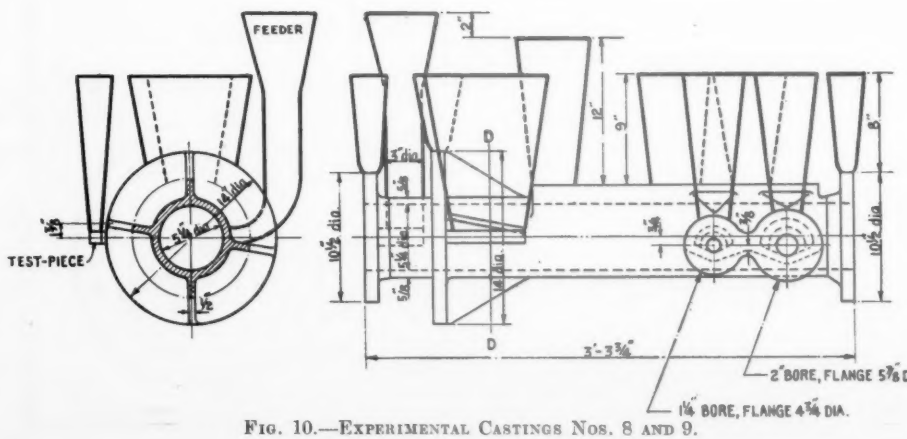

Fig. 10.—Experimental Castings Nos. 8 and 9.

Smoke Abatement.—The National Smoke Abatement Society has published a reprint of John Evelyn's pamphlet "Fumifugium: or the Inconvenience of the Aer and Smoake of London Dissipated," first issued in 1661. Miss Rose Macaulay has contributed an interesting introduction to this reprint, which latter indicates very aptly the vast progress made since Evelyn's time in combating the smoke nuisance and what still remains to be done in this direction. Copies of this reprint may be obtained from the Society at 25, King Street, Manchester, 2. (Price 6d. in paper covers; or 1s. 6d. bound in cloth.)

Patent Incandescent High Production
OIL FIRED
Radiant Heat Muffle Furnaces
for VITREOUS PROCESS ENAMELLING

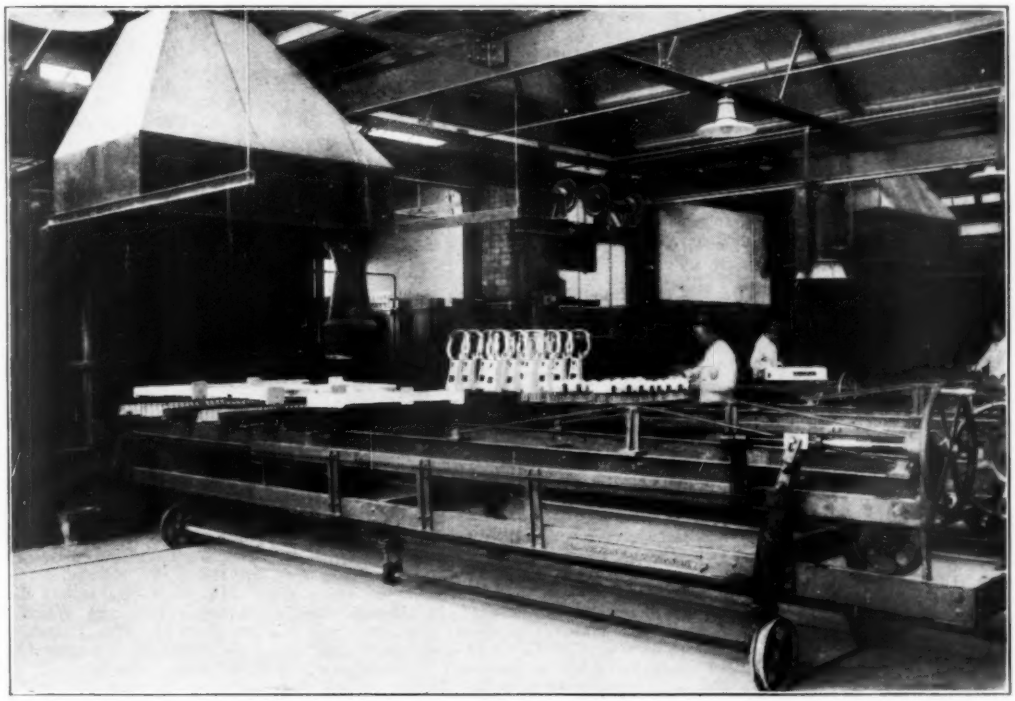

Illustration shows a battery of Oil Fired Muffle Furnaces, 12 ft. 0 in. × 4 ft. 6in. wide which operate on maximum production with a fuel consumption of 6 gallons per hour.

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This Week's News in Brief.

Trade Talk.

MESSRS. W. SHAW & COMPANY, LIMITED, of the Wellington Cast Steel Foundry, Middlesbrough, have secured the contract for the supply of the keel blocks for the new Southampton Dock.

THE CONSETT IRON COMPANY, LIMITED, has secured the contract for the steelwork for a new 8,000-ton vessel under construction at Messrs. John Readhead & Son's shipyard at South Shields.

A GARDEN FÊTE was held in the grounds of Moorcroft House, Renfrew, on May 27 in aid of the sports prize fund of the works athletic club of Messrs. Babcock & Wilcox, Limited. The opening was performed by Mrs. H. L. Critchley, wife of the general manager.

THE IMPORT DUTIES (DRAWBACK) (No. 5) ORDER, 1933, issued by the Treasury recently, puts into operation a scheme for allowance of drawback on cupro-nickel and gilding-metal coated steel cups used for the manufacture of bullets in certain types of metallic ammunition.

AS A RESULT of the examination of the employers' books for the months of March and April, the auditors have reported to the secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board that the average net selling price was £9 14s., which means that the workers' wages will be reduced by 2½ per cent. on basis rates.

PRINCE GEORGE, while in Lancashire recently, paid a visit to the works in Manchester of Messrs. Mather & Platt, Limited. The Prince, who was accompanied by the chairman of the company, Mr. L. E. Mather, visited the pump, electrical, textile, food-canning and fire departments, and displayed a keen interest in the variety of processes seen.

MR. F. W. JOPLING, manager of the construction department of the Britannia Works, Middlesbrough, of Messrs. Dorman, Long & Company, Limited, having retired owing to ill-health, the appointment has been given to MR. ALFRED MARTIN, who was chief assistant to Mr. Lawrence Ennis during the building of the Sydney Harbour Bridge. Mr. Martin, who has been in the employ of the firm since 1901, has only recently returned from Australia.

NEGOTIATIONS ARE UNDERSTOOD to be in progress for reopening three Low Moor ironworks, near Bradford, for the manufacture of an important range of new metal alloys from scrap iron, the nature of which has aroused great interest among metallurgists and leaders of the iron and steel industry. Great claims are made for the process, which is the invention of Mr. H. J. Henbrey, of Bradford, who was prominently connected with the Low Moor works, before they were closed.

On the initiative of the Rhodesian and Canadian copper producers a meeting of leading representatives of the copper trade was held in London on May 22, when it was decided to form a copper development association. The new association will have as its object the collection of technical and cognate information on the use of copper and the dissemination of this information to consumers and potential users of copper. The association will be under the control of a council on which the various interests will have representation, and immediately after incorporation will start work with offices at Thames House, Millbank, London, S.W.1.

Mr. Guy Locock, Director of the Federation of British Industries, has sent a letter on behalf of the F.B.I. to the President of the Board of Trade expressing grave apprehension as to the main lines of policy which appear so far to have guided negotiations for commercial agreements with foreign countries. The letter states that, even with the protective duties which have been imposed in this country, Great Britain still offers to the foreigner one of the most valuable markets in the world. It should be possible to obtain from foreign countries who wish to retain their share of this market valuable concessions without any necessity for concessions on our part.

IN ORDER to carry out the intention of the directors of the Coltness Iron Company, Limited, to reduce the paid-up capital of the company by returning 5s. per share to the holders of the ordinary shares, separate meetings of the holders of the two classes of preference shares and of the company will be held on June 16. The resolution to be submitted at each meeting will be to the effect that, in respect of each ordinary share in the capital of the company upon which the sum of £1 has been paid up, capital be paid off to the extent of 5s. (the capital represented thereby being in excess of the requirements of the company) upon the footing that the amount returned, or any part thereof, may be called up again.

THE MOTHERWELL TUBE WORKERS of Messrs. Stewart & Lloyds' Vulcan Works, Motherwell, have received the welcome news that the works will continue in operation. As was previously reported, the workers and staff received official notice that the works were to close down at the end of May. As the result of a large Scottish order and an important South African contract for a new water pipe line, the works at Motherwell will be kept at full pressure for some time. Normally about 200 men are employed at the Vulcan works, and it is anticipated that the full complement of employees will be kept going day and night for at least four months. The 5,000 tons steel required for the pipe line will be made at Messrs. Stewart & Lloyds' Clydesdale Steel Works, Mossend.

ELECTRIC WELDING, a recent development in shipbuilding which will displace a number of shipyard workers and create an entirely new class of workers, was the subject of a conference in Edinburgh between representatives of the employers and employees. Mr. J. B. Hutchison, of Greenock, acted as chairman for the employers and Mr. Will Sherwood led for the employees. Mr. Hutchison indicated that the process, which had already been tried in industry, would in the near future make further progress. He emphasised the importance of the development of welding in this country proceeding as rapidly and as smoothly as possible on economic lines in order to meet competition from other countries. The Employers' Federation recognised that a rearrangement of the existing methods and practice might be involved which would affect all classes of workmen.

CONSEQUENT UPON THE DECISION of the Chancellor of the Exchequer to exempt coastwise shipping from the heavy-oil tax, Messrs. Coast Lines, Limited, have given orders to renew the contracts which were cancelled at Leith and Ardrossan. Work on the 1,400-ton motor coaster ordered from Messrs. Henry Robb, Limited, and for which the engines were to be supplied by Messrs. British Auxiliaries, Limited, Govan, Glasgow, will be started immediately in order that the vessel may be ready for trials in October. The vessel will be the largest motor-ship in the British coastal fleet. The vessel to be built at Ardrossan is a 450-ton motor coaster with engines of the Kromhout type built by Messrs. J. G. Kincaid, Greenock. It is also expected that negotiations for the placing of the two Everard boats with Messrs. George Brown & Company, Greenock, will be renewed at once.

Company Reports.

J. Stone & Company, Limited.—Profit in 1932, £14,801; brought in, £145,689; preference dividend, £39,000; carried forward, £121,490.

Park Gate Iron & Steel Company, Limited.—Profit, £40,459; brought in, £11,045; written off for depreciation, £30,000; dividend of 1 per cent., £14,062; carried forward, £7,442.

British Oxygen Company, Limited.—Net profit, £100,242; brought in, £64,365; final dividend of 3 per cent., making 5 per cent. for the year, and a bonus of 1½ per cent.; carried forward, £54,491.

Siemens Bros. & Company, Limited.—Profit, £291,449; interest on and redemption of 4½ per cent. debenture stock, £67,439; one year's dividend of 10 per cent. on the cumulative preference shares, £55,000; interim dividend of 2½ per cent. on the ordinary shares, £61,250; final dividend of 4 per cent., making 6½ per cent. for the year, £98,000; brought in, £372,155; carried forward, £381,916.

Contracts Open.

Cattistock, June 15.—Supply and laying of one mile of 4-in., 3-in. and 2-in. water mains, for the Dorchester Rural District Council. Mr. A. J. Price, engineer, Municipal Offices, Yeovil.

Turkey, June 15.—Cast-iron pipes, tanks, boilers, winches, etc., for the Turkish State Railways. The Department of Overseas Trade. (Reference G.Y. 12,624.)

Personal.

LORD MESTON has resigned from the board of the English Electric Company, Limited. SIR GERALD F. TALBOT has been appointed a director of the company.

ARRANGEMENTS HAVE BEEN MADE for the presentation of a testimonial to ex-Provost Shanks, J.P., Denny, in appreciation of his services to the town. The ceremony took place at a public dinner in the Masonic Hall, Denny, on May 30. Mr. Shanks is the chairman of Messrs. Cruikshank & Company, Limited, Denny Iron Works, manufacturers of steel, malleable and grey-iron castings.

MR. G. LILLIE, who for over 22 years has been in charge of the foundries of Messrs. R. & W. Hawthorn, Leslie & Company, Limited, retired on May 27. A striking tribute was paid by the foundry staff, for, although the foundry has only resumed a short while after a long period of idleness, he was presented by them with a handsome umbrella with inscribed handle. On May 26, Mr. W. Smith, on behalf of the officials and foremen of St. Peter's Works, made a presentation of a barometer, and an alligator-skin handbag for Mrs. Lillie. Mr. Lillie is a comparatively young man, and his many friends will wish both himself and Mrs. Lillie good health and every happiness.

Obituary.

MR. REES WILLIAMS REES, of Cefn Coed, for many years traffic manager at the Ebbw Vale Ironworks, has died, aged 73.

SIR JOHN WORMALD, M.Inst.C.E., died at his home on Saturday, May 20, at the age of 73. Sir John, who retired from business about nine years ago, was for some years a director of Messrs. Mather & Platt, Limited, engineers, of Manchester.

MR. THOMAS SANDERSON, who was associated with the firm of Sidney Flavel & Company, Limited, of Leamington, for 65 years, died on May 19, at the age of 88. During this long period of activity he was in turn works clerk, traveller, general manager, secretary and director during four generations of the Flavel family.

MR. R. J. HATTON, a director of Messrs. W. T. Henley's Telegraph Works Company, Limited, died on May 17. Mr. Hatton, who was born in 1854, had served the company for over 50 years. He was appointed manager of the Woolwich works on January 1, 1884, and retained that position until January, 1920, when he was appointed consulting engineer to the company, in which capacity he was acting until the time of his death. Mr. Hatton was appointed a director of the company in 1912.

THE DEATH OCCURRED at his residence in Victoria Road, Grangemouth, on May 26, of Mr. Boston Harley, shipping manager of Carron Company, and a brother of Mr. Andrew Harley, Past-President of the Institute of British Foundrymen. Mr. Harley's family has had a long connection with Carron Company, the first member having come with Dr. Roebuck, who founded the ironworks. Mr. Harley, who was 65 years of age, had himself been employed by Carron Company for 52 years.

New Companies.

Weiss & Biheller (Metals), Limited.—Capital £3,000. Subscriber: R. Woolf, Kennan's House, Crown Court, London, E.C.2.

Welding Supplies, Limited, Wood Wharf, Greenwich, London, S.E.10.—Capital £7,500. Directors: T. M. Aitken, W. H. Nicholson and W. Edstrom.

Speaking at Gresham College last week, Sir George Newman pointed out that in recent years there had been a great reduction in the incidence of occupational diseases. The death-rate due to dust diseases was now very small. In 1931 only nine people in Britain died from asbestiosis, and their average age was 40. The average of those who died from silicosis was 54. Lead poisoning was being abolished. Where it did happen it was usually because people did not take reasonable precautions. While the dangerous trades had multiplied a hundredfold, sickness and mortality, instead of multiplying, had been greatly reduced, in some cases to vanishing point. The improvement was due to the introduction of the factory and health laws.

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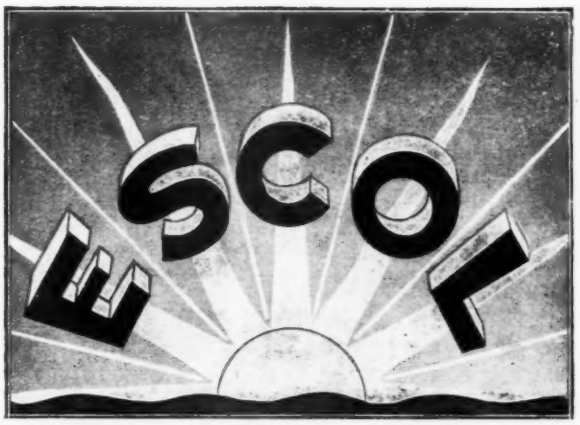

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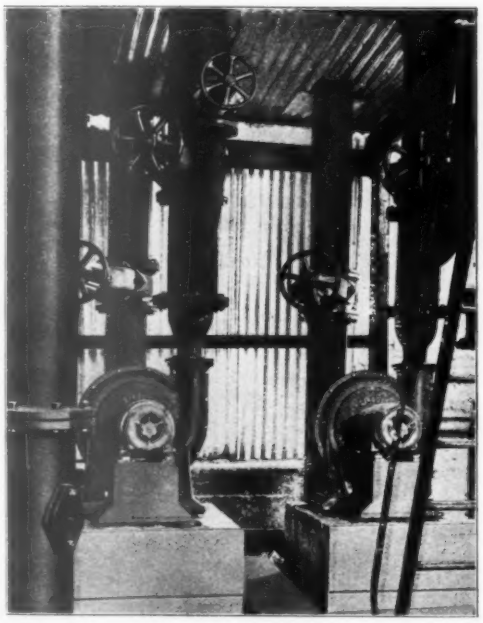

No. S.F. 26 dealing with "Sirocco" Fan Manufactures for moderate and high pressures. It includes some interesting examples of recent installations and contains detailed and accurate information concerning duties, weights and dimensions for the wide range of sizes and designs listed. In addition, numerous tables assist in determining the most suitable "Sirocco" Fan Equipment for use under diverse operating conditions.

A copy for reference is indispensable.

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Raw Material Markets.

A firm feeling of confidence in a revival of trade is apparent in the iron and steel markets, although the obstacles to international commerce show little sign of relaxation. Home consumption of pig-iron is reported to be showing a gradual increase. The British semi-finished steel works are experiencing increased activity, as a result of the enhanced prices ruling on the Continent since the re-establishment of the European cartel. The demand for finished steel remains limited, owing to the paucity of shipbuilding and heavy engineering work.

Pig-Iron.

MIDDLESBROUGH.—Hardly any new business of any importance is being transacted in Cleveland pig-iron at the moment. Users generally have contracted for their requirements until the end of the half-year, and contract deliveries are quite sufficient. A few occasional sales of small quantities are put through at the new minimum prices. There has been little buying on the export side. The practical effect of the new Scandinavian trade agreements has yet to make itself felt, although a considerable amount of business is eventually expected from this source. There are only two blast furnaces producing Cleveland iron for merchanting purposes, and their output is well absorbed. All new business with British buyers is on the basis of the following minimum rates:—No. 3 Cleveland G.M.B., 62s. 6d. per ton delivered Middlesbrough area, 64s. 6d. delivered North-East Coast, 62s. 9d. delivered Glasgow area. No. 1 foundry iron is 2s. 6d. per ton more than the above prices and 1s. less than No. 3 is quoted for No. 4 foundry and No. 4 forge.

In spite of the lack of Continental support, the consumption of East Coast hematite remains at a steady level. The steelworks in Sheffield and South Wales are taking good deliveries. The one unsatisfactory feature of the situation is the continued existence of heavy stocks of unsold material. Were it not for these, prices would certainly show an advance, as the present level leaves little or no margin of profit. For the present, however, quotations remain at 59s. for East Coast mixed numbers and 59s. 6d. for No. 1 grade.

LANCASHIRE.—During the last few days there has been a lull in buying; this was to be expected, as a fair number of pig-iron sales for delivery over the next two or three months have been concluded. Makers of textile machinery fail to show any increase in activity, although other branches of the Lancashire foundry industry are somewhat better engaged. There has been no alteration in the price position of pig-iron, values for delivery in the Manchester zone being on the basis of 67s. per ton for Derbyshire, Staffordshire and North-East Coast brands of No. 3, with Northamptonshire at 65s. 6d., Derbyshire forge iron at 62s., Scottish foundry at around 82s., West Coast hematite at about 80s. 6d. and East Coast hematite at 5s. less.

MIDLANDS.—The pig-iron demand is maintained at a steady level, but the furnaces are still having to put a small proportion of their make into stock. A meeting of the producers was held last week, when the standing zone rates were re-affirmed, viz., 62s. 6d. for Northamptonshire No. 3 and 66s. for North Staffordshire, Derbyshire and Lincolnshire No. 3, including delivery to Birmingham and Black Country stations. Cleveland No. 3 is on offer at 66s. per ton. Continental foundry iron is not competitive in this area at the moment. There is an improved request for special qualities of pig-iron; medium- and low-phosphorus grades are quoted at between 70s. and 85s. per ton delivered this district, according to analysis. Scottish No. 3 ranges between 83s. and 85s. per ton delivered. Hematite prices are unaltered at 84s. 6d. for West Coast and 74s. 6d. to 77s. 6d. for Welsh and East Coast No. 3 or mixed numbers.

SCOTLAND.—Pig-iron consumers are generally short of work, with the exception of sugar-machinery makers. Idle time is pronounced at the light-castings foundries. The output of the seven furnaces in operation is not being fully absorbed. There is no change to report in prices and the official minimum of 65s. f.o.t. furnaces for No. 3 foundry remains in force, with an extra of 2s. 6d. per ton for No. 1. The demand for No. 1 is very limited. No. 3 Middlesbrough is at 59s. 9d. at Falkirk and 62s. 9d. at Glasgow, with No. 4 foundry quoted at 1s. less. Northamptonshire irons are quoted at 57s. 3d. for No. 3 foundry at Falkirk.

Coke.

New business remains very limited in the foundry-coke market. Quotations for best grades of Durham foundry coke vary from 36s. 6d. to 38s. per ton. Other grades are available at down to 35s. Prices of Welsh cokes range from 30s. to 45s. per ton, according to analysis and tonnage. The above quotations are all for delivery in the Birmingham area.

Steel.

Quiet conditions have developed in the steel market, according to the weekly official report of the London Iron and Steel Exchange. The situation in the semi-finished steel department has moved definitely in favour of the British works, as the present prices of Continental material are not competitive in this country. It is not anticipated that the new Continental prices, to be issued shortly, will change this position. Trading in finished materials is on a good scale, although the business is spread unevenly over the market. Quieter conditions have developed in some sections of the home market, but recently export buying has improved slightly.

Scrap.

Sluggish conditions prevail again in the Cleveland scrap-iron trade. Heavy supplies are offered on the market, as several big local works have ceased taking deliveries. Good cast-iron machinery scrap remains at 40s. and ordinary heavy at 37s. 6d. Light metal is at 34s. 6d. per ton. In the Midlands, there is a steady market for machinery metal at 47s. 6d., and for the heavy grade at 45s. Clean light metal is at 37s. 6d., delivered. In South Wales, heavy cast iron in large pieces and furnace sizes remains quiet at 43s. 6d. There is only a restricted sale for machinery scrap at 48s. to 50s., but light metal is in slightly better request at 38s. per ton. There is a slightly better demand for scrap-iron in Scotland.

Metals.

Copper.—The standard market has shown a very firm tone, quotations rising on Wednesday to over £38. Tube-makers in this country have been on the market for increasing quantities of metal, but activity in the wire and cable industries remains limited. The consumption of copper is also stated to be increasing on the Continent, particularly in the German brass- and copper-manufacturing industries. These factors, combined with an outburst of optimistic sentiment in America, have resulted in notable activity on the London Metal Exchange. The turnover on Monday was about 3,600 tons. It is difficult to get a clear view of the actual situation in the United States, but it is reported that further curtailments of mine outputs are being put into force.

The week's prices have been as follow :—

Cash.—Thursday, £34 12s. 6d. to £34 13s. 9d.; Friday, £35 3s. 9d. to £35 5s.; Monday, £36 12s. 6d. to £36 15s.; Tuesday, £37 10s. to £37 12s. 6d.; Wednesday, £38 5s. to £38 6s. 3d.

Three Months. — Thursday, £34 17s. 6d. to £34 18s. 9d.; Friday, £35 7s. 6d. to £35 8s. 9d.; Monday, £36 18s. 9d. to £37; Tuesday, £37 15s. to £37 16s. 3d.; Wednesday, £38 10s. to £38 11s. 3d.

Tin. — Standard metal rose yesterday to over £210, following a period of intensified buying. There is a marked shortage of prompt metal on the market, owing to the firm control exercised under the restriction scheme. Consumers have been showing more anxiety with regard to covering their requirements, and a certain amount of buying has been seen in this direction.

Daily quotations :—

Cash.—Thursday, £191 17s. 6d. to £192; Friday, £190 17s. 6d. to £191; Monday, £198 2s. 6d. to £198 5s.; Tuesday, £199 7s. 6d. to £199 10s.; Wednesday, £210 5s. to £210 10s.

Three Months. — Thursday, £191 15s. to £192; Friday, £190 12s. 6d. to £190 17s. 6d.; Monday, £198 7s. 6d. to £198 10s.; Tuesday, £199 5s. to £199 7s. 6d.; Wednesday, £210 5s. to £210 10s.

Spelter.—With the exception of those engaged in the galvanising trade, consumers in this country continue to take good deliveries of copper, and the market displays a strong tone. The monthly world statistics show that, with the exception of the U.S.A., consumption is outpacing current production in a manner very satisfying to the sponsors of the present international cartel system. The latter comes to an end shortly, and the question of its renewal is to be discussed by the members.

Price fluctuations :—

Ordinary. — Thursday, £15 12s. 6d.; Friday, £15 17s. 6d.; Monday, £16 2s. 6d.; Tuesday, £16 5s.; Wednesday, £16 17s. 6d.

Lead.—There is a steady demand for this metal, especially for the manufacture of lead pipes and sheets, owing to the activity in the building industry. Quotations have shown a firm tone, rising at one time to the highest level reached this year.

Daily market prices :—

Soft Foreign (Prompt).—Thursday, £12 3s. 9d.; Friday, £12 7s. 6d.; Monday, £12 13s. 9d.; Tuesday, £13; Wednesday, £13 13s. 9d.

Application of X-Rays in Industry.

During the past few years considerable headway has been made in connection with the application of X-rays to Industry. Amongst foundrymen in particular the subject has come into great prominence, more so perhaps since the publication of the First Steel Castings Report. Moreover, it seems to be generally recognised that for the examination of welds and fabricated structures, X-rays have a definite sphere of usefulness.

In foundry practice X-ray inspection has frequently proved its worth in the development of experimental castings which may ultimately be standardised. In many instances, X-rays give the only clue to an inherent flaw which a slight modification in the design of the casting would ultimately remove. In the construction of high-speed engines, as in the case of aircraft, for instance, where the weight-power ratio has to be closely controlled, radiographic inspection of vital components is definitely indicated.

The way in which X-rays have been applied to engineering problems at the Research Department, Woolwich, seems definitely to indicate that the Services at least are fully alive to the possibilities.

With modern apparatus and technique some striking results can be achieved. A widespread impression that the apparatus for industrial X-ray examination is very costly and requires skilled personnel for its operation is, perhaps, one of the reasons why X-ray inspection has not been more generally adopted.

The elimination of the high tension hazard and complete protection against unwanted radiation should, however, do a good deal to bring X-rays into line with other accepted and practicable methods of testing.

It is interesting to note that an industrial X-ray laboratory is now in existence which undertakes the radiographic examination of customer specimens, assembled articles and components for almost every class of industry. In the case of examinations of such articles as castings, welded boilers and pressure vessels, etc., which would be difficult to transport, special mobile equipment is available which permits of the job handled on site.

Philips Industrial (X-ray Division), 145, Charing Cross Road, London, W.C.2, who are responsible for the innovation, state that the need for such a service was brought home to them very forcibly by many engineers who were faced with problems in which X-rays offered a definite solution, but were not in themselves sufficient to warrant the purchase of special equipment.

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A very reliable, non-porous, copper alloy. Largely used for die-castings as well as for sand-castings. Average tensile strength, sand-cast, 7 tons/sq. in. Chill-cast 10·5 tons sq. in. Percentage elongation on 2", 2·4 respectively.

The standard B.A.Co. ingot, weighing 6½ lbs., is used for aluminium alloys mixed to B.A.Co., British Standard and other specifications.

The standard B.A.Co. notched bar, weighing 2½ lbs. is used for virgin aluminium, 98/99% and higher purities.

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BRANDS "DALZELL", "GLENGARNOCK", "CLYDE" & "MONKLAND"
HIGH GRADE HEMATITE PIG IRON
SPECIAL & ORDINARY FOUNDRY QUALITIES & FORGE
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GUARANTEED NOT EXCEEDING 3·0% MAX.
COLVILLES LTD
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WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	38	5	0
Three months	38	10	0
Electrolytic	43	5	0
Tough	40	5	0
Best selected	40	15	0
Sheets	68	0	0
India	50	10	0
Wire bars	42	10	0
Do., July	42	12	6
Do., August	42	15	0
Ingot bars	42	10	0
H.C. wire rods	44	0	0
Off. av. cash, April	29	12	5½
Do., 3 mths., April	29	16	6¾
Do., Sttlmnt., April	29	12	9½
Do., Electro, April	33	19	4½
Do., B.S., April	32	14	4½
Do., wire bars, April	34	5	1½
Solid drawn tubes			10d.
Brazed tubes			10d.
Wire			7d.

BRASS.

Solid drawn tubes	9d.
Brazed tubes	11d.
Rods, drawn	8½d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7½d.
Wire	7½d.
Rolled metal	7½d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN.

	£	s.	d.
Standard cash	210	5	0
Three months	210	5	0
English	210	15	0
Bars	212	5	0
Straits	226	17	6
Australian	219	7	6
Eastern	225	2	6
Banca (nom.)	225	7	6
Off. av. cash, April	158	0	4½
Do., 3 mths., April	158	15	1⅝
Do., Sttlmt., April	158	0	3½

SPELTER.

	£	s.	d.
Ordinary	16	17	6
Remelted	16	12	6
Hard	14	5	0
Electro 99.9	19	0	0
English	17	10	0
India	15	5	0
Zinc dust	19	0	0
Zinc ashes	2	7	6
Off. aver., April	15	1	7½
Aver. spot, April	14	19	0½

LEAD.

	£	s.	d.
Soft foreign ppt.	13	13	9
Empire	13	17	6
English	15	0	0
Off. average, April	10	19	11½
Average spot, April	10	17	5½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	24	10	0
Do., V.M. ex-whse.	23	5	0
Rods	28	0	0
Boiler plates		—	
Battery plates		—	

ANTIMONY.

	£	s.	d.	£	s.	d.
English	35	0	0 to	40	0	0
Chinese				26	10	0
Crude					—	

QUICKSILVER.

	£	s.	d.	£	s.	d.
Quicksilver	9	0	0 to	9	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro silicon—	
25%	£7 15 0
45/50%	£13 17 6
75%	£19 12 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free of Mo.	6/3 per lb.
Ferro-titanium—	
23/25% carbon-free	10d. lb.
Ferro-phosphorus, 20/25%	£17 17 6
Ferro-tungsten—	
80/85%	1/6 lb.
Tungsten metal powder—	
98/99%	1/9 lb.
Ferro-chrome—	
2/4% car.	£28 5 0
4/6% car.	£21 15 0
6/8% car.	£20 15 0
8/10% car.	£20 0 0
Ferro-chrome—	
Max. 2% car.	£32 10 0
Max. 1% car.	£35 5 0
Max. 0.70% car.	£39 2 6
70% carbon-free	11d.
Nickel—99.5/100%	£225 to £230
"F" nickel shot	£202 10 0
Ferro-cobalt	5/9 lb.
Aluminium 98/99%	£100 0 0
Metallic chromium—	
96/98%	2/8 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/4 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten 2s. 0d.
Finished bars, 18% tungsten 2s. 9d.
Per lb. net, d/d buyers' works.

Extras—
Rounds and squares, 3 in. and over 4d. lb.
Rounds and squares, under ½ in. to ¼ in. 3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in. 1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in. 3d. lb.
Do., under ½ in. × ¼ in. 1/- lb.
Bevels of approved sizes and sections 6d. lb.
Bars cut to length, 10% extra.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy steel				2	5	0
Bundled steel and shrngs.	1	17	6 to	2	4	0
Mixed iron and steel	2	0	0 to	2	1	0
Heavy cast iron				2	3	6
Good machinery	2	8	0 to	2	10	0
Cleveland—						
Heavy steel				1	17	6
Steel turnings				1	11	6
Cast-iron borings				1	2	0
Heavy forge				2	10	0
W.I. piling scrap				2	0	0
Cast-iron scrap	1	17	6 to	2	0	0
Midlands—						
Light cast-iron scrap				1	17	6
Heavy wrought iron				2	5	0
Steel turnings, f.o.r.				1	4	6
Scotland—						
Heavy steel	1	17	6 to	1	18	6
Ordinary cast iron	2	4	0 to	2	5	0
Engineers' turnings	1	12	6 to	1	13	6
Cast-iron borings				1	12	6
Wrought-iron piling				2	1	3
Heavy machinery	2	8	6 to	2	9	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	28	0	0
Brass	19	0	0
Lead (less usual draft)	12	0	0
Tea lead	10	0	0
Zinc	10	0	0
New aluminium cuttings	74	0	0
Braziery copper	24	0	0
Gunmetal	22	0	0
Hollow pewter	115	0	0
Shaped black pewter	85	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	65/-
Foundry No. 3	62/6
,, at Falkirk	59/9
,, at Glasgow	62/9
Foundry No. 4	61/6
Forge No. 4	61/6
Hematite No. 1, f.o.t.	59/6
Hematite M/Nos., f.o.t.	59/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	68/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	62/-
,, No. 3 fdry.	66/-
Northants forge	58/6
,, fdry. No. 3	62/6
,, fdry. No. 1	65/6
Derbyshire forge	62/-
,, fdry. No. 3	66/-
,, fdry. No. 1	69/-
Scotland—	
Foundry No. 1	67/6
,, No. 3	65/-
Hem. M/Nos. d/d	66/-
Sheffield (d/d district)—	
Derby forge	59/6
,, fdry. No. 3	63/6
Lincs forge	59/6
,, fdry. No. 3	63/6
E.C. hematite	73/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/-
Clyde, No. 3	82/-
Monkland, No. 3	82/-
Summerlee, No. 3	82/-
Eglinton, No. 3	82/-
Gartsherrie, No. 3	82/-
Shotts, No. 3	82/-

FINISHED IRON AND STEEL.

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	9	0	0 to	9	15	0
Nut and bolt iron	6	15	0 to	7	10	0
Hoops	10	10	0 to	12	0	0
Marked bars (Staffs) f.o.t.				12	0	0
Gas strip	10	10	0 to	12	0	0
Bolts and nuts, ¾ in. × 4 in.				12	17	6
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.				8	5	0
Chequer plts.				10	7	6
Angles				8	7	6
Tees				9	7	6
Joists				8	15	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ¾ in. (Untested)			6 15 0 & up.			
Flats—8 in. wide and over				8	12	6
,, under 8 in. and over 5 in.				8	17	6
Rails, heavy	8	5	0 to	8	10	0
Fishplates				12	0	0
Hoops (Staffs)	9	10	0 & up.			
Black sheets, 24g. (10-t. lots)				9	15	0
Galv. cor. shts.	,,			12	0	0
Galv. flat shts.	,,			12	10	0
Galv. fencing wire, 8g. plain				14	0	0
Billets, soft	5	0	0 to	5	12	6
Billets, hard	6	12	6 to	7	2	6
Sheet bars	4	15	0 to	5	2	6
Tin bars				4	15	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	11d.
Sheet to 10 w.g.	12d.
Wire	12½d.
Rods	11d.
Tubes	15½d.
Castings	13d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1¼ to 1/7¼
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	15.34
No. 2 foundry, Valley	14.50
No. 2 foundry, Birm.	12.00
Basic	15.89
Bessemer	16.89
Malleable	16.39
Grey forge	16.89
Ferro-mang. 80%, seaboard	68.00
O.-h. rails, h'y, at mill	40.00
Billets	26.00
Sheet bars	26.00
Wire rods	35.00
	Cents.
Iron bars, Phila.	1.86
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Steel hoops	1.55
Sheets, black, No. 24	2.00
Sheets, galv., No. 24	2.70
Wire nails	1.85
Plain wire	2.10
Barbed wire, galv.	2.35
Tinplates, 100-lb. box	$4.25

COKE (at ovens).

Welsh foundry	20/- to 22/6
,, furnace	15/- to 16/-
Durham and Northumberland—	
,, foundry	21/- to 25/-
,, furnace	13/3
Midlands, foundry	—
,, furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	16/6 to 16/9
,,	28×20 ,,	33/- to 33/6
,,	20×10 ,,	23/9
,,	18¾×14 ,,	17/1½
C.W.	20×14 ,,	15/3
,,	28×20 ,,	31/-
,,	20×10 ,,	—
,,	18¾×14 ,,	—

SWEDISH CHARCOAL IRON & STEEL.

	£	s.	d.	£	s.	d.
Pig-iron	6	0	0 to	7	0	0
Bars-hammered, basis	16	10	0 to	17	0	0
Bars and nail-rods, rolled, basis	15	17	6 to	16	5	0
Blooms	10	0	0 to	12	0	0
Keg steel	32	0	0 to	33	0	0
Faggot steel	18	0	0 to	23	0	0
Bars and rods dead soft, st'l	10	0	0 to	12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

XUM

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£ s. d.	
May	25 ..	34 12 6	dec. 2/6
,,	26 ..	35 3 9	inc. 11/3
,,	29 ..	36 12 6	,, 28/9
,,	30 ..	37 10 0	,, 17/6
,,	31 ..	38 5 0	,, 15/-

Electrolytic Copper.

		£ s. d.	
May	25 ..	39 0 0	No change
,,	26 ..	39 10 0	inc. 10/-
,,	29 ..	40 10 0	,, 20/-
,,	30 ..	41 10 0	,, 20/-
,,	31 ..	43 5 0	inc. 35/-

Standard Tin (cash).

		£ s. d.	
May	25 ..	191 17 6	inc. 30/-
,,	26 ..	190 17 6	dec. 20/-
,,	29 ..	198 2 6	inc. 145/-
,,	30 ..	199 7 6	,, 25/-
,,	31 ..	210 5 0	,, 217/6

Tin (English ingots).

		£ s. d.	
May	25 ..	193 5 0	inc. 30 -
,,	26 ..	192 5 0	dec. 20/-
,,	29 ..	199 10 0	inc. 145 -
,,	30 ..	200 15 0	,, 25/-
,,	31 ..	210 15 0	,, 200/-

Spelter (ordinary).

		£ s. d.	
May	25 ..	15 12 6	dec. 2/6
,,	26 ..	15 17 6	inc. 5 -
,,	29 ..	16 2 6	,, 5/-
,,	30 ..	16 5 0	,, 2/6
,,	31 ..	16 17 6	,, 12/6

Spelter (Electro, 99.9 per cent.).

		£ s. d.	
May	25 ..	17 15 0	No change
,,	26 ..	18 2 6	inc. 7/6
,,	29 ..	18 7 6	,, 5/-
,,	30 ..	18 10 0	,, 2/6
,,	31 ..	19 0 0	,, 10/-

Zinc Sheets (English).

		£ s. d.	
May	25 ..	24 10 0	inc. 10/-
,,	26 ..	24 10 0	No change
,,	29 ..	24 10 0	,, ,,
,,	30 ..	24 10 0	,, ,,
,,	31 ..	24 10 0	,, ,,

Lead (English).

		£ s. d.	
May	25 ..	13 10 0	No change
,,	26 ..	13 15 0	inc. 5/-
,,	29 ..	14 0 0	,, 5/-
,,	30 ..	14 10 0	,, 10/-
,,	31 ..	15 0 0	,, 10/-

AVERAGE MONTHLY PRICES OF RUBIO ORE (MIDDLESBROUGH).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1895	0 12 0	0 12 0	0 11 10	0 12 0	0 12 0	0 12 3	0 12 3	0 12 4	0 12 4	0 12 6	0 12 7	0 12 6	0 12 2½
1896	0 12 6	0 12 6	0 12 9	0 12 9	0 12 9	0 12 7	0 12 9	0 12 9	0 12 9	0 13 6	0 15 0	0 14 9	0 13 1
1897	0 15 3	0 15 6	0 15 3	0 15 0	0 14 0	0 14 3	0 14 3	0 14 0	0 14 0	0 15 0	0 14 3	0 15 3	0 14 8
1898	0 15 0	0 14 4	0 14 9	0 14 6	0 15 0	0 15 0	0 14 0	0 14 0	0 14 0	0 14 9	0 15 0	0 14 9	0 14 7
1899	0 15 0	0 15 3	0 15 6	0 15 6	0 15 9	0 16 0	0 18 0	0 17 9	0 18 0	0 19 0	1 0 0	0 16 11½	
1900	1 1 0	1 0 6	1 1 0	1 0 9	1 1 0	1 1 0	1 1 3	1 1 6	1 1 3	1 1 3	1 0 0	0 18 0	1 0 6½
1901	0 17 6	0 16 0	0 15 0	0 14 6	0 15 6	0 15 9	0 14 9	0 15 3	0 15 9	0 15 9	0 15 9	0 15 9	0 15 7½
1902	0 15 6	0 15 0	0 16 0	0 16 0	0 15 6	0 15 3	0 15 6	0 16 0	0 16 0	0 16 0	0 15 9	0 15 6	0 15 8½
1903	0 15 6	0 16 0	0 16 6	0 16 3	0 16 3	0 16 10	0 15 9	0 15 6	0 15 6	0 14 9	0 14 9	0 15 1	0 15 6
1904	0 14 9	0 15 3	0 15 1	0 15 4	0 15 3	0 15 0	0 14 5	0 14 6	0 14 6	0 14 6	0 14 6	0 14 7	0 14 9½
1905	0 15 3	0 15 6	0 15 0	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 16 6	0 18 6	0 18 9	0 18 9	0 16 3½
1906	1 0 0	1 1 6	1 0 0	1 0 0	0 19 6	1 0 0	0 19 6	0 19 4	1 0 6	1 1 6	1 1 9	1 3 6	1 0 7
1907	1 3 6	1 2 6	1 2 6	1 2 0	1 1 6	1 2 3	1 2 3	1 2 0	1 1 0	0 19 0	0 18 9	0 17 6	1 1 3½
1908	0 16 6	0 15 0	0 15 6	0 15 6	0 15 3	0 15 0	0 15 0	0 14 9	0 15 0	0 16 0	0 16 0	0 16 0	0 15 8½
1909	0 15 9	0 16 3	0 16 0	0 16 0	0 16 3	0 16 6	0 16 0	0 16 0	0 17 0	0 17 0	0 17 6	0 17 6	0 16 6
1910	1 0 4	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 3	1 0 3	1 0 6½	1 1 3	1 1 5	1 0 9½
1911	1 2 2½	1 2 6	1 2 6	1 1 11½	1 0 11½	0 19 6	0 19 0	0 19 0	0 19 1½	0 19 6	1 0 0½	1 1 6½	1 0 7½
1912	1 2 3	1 2 6	1 2 6	1 1 1½	1 1 6	1 1 6	1 1 6	1 2 3	1 2 6	1 3 0	1 3 0	1 2 11	1 2 2½
1913	1 2 9	1 2 2	1 1 7½	1 1 6	1 0 8½	1 0 0	1 0 0	1 0 0	0 19 10½	0 19 1½	0 19 0	0 19 0	1 0 8½
1914	0 18 7½	0 18 0	0 18 0	0 17 9	0 17 6	0 17 6	0 17 1½	0 19 7½	0 18 11½	0 17 10½	0 18 7½	1 1 0½	0 18 5½
1915	1 7 7½	1 8 6	1 9 3	1 10 2½	1 8 6	1 6 4	1 5 10½	1 6 0	1 6 10½	1 10 8½	1 13 0	1 17 10	1 9 1½
1916	1 18 6	2 0 1½	2 2 6½	2 0 6½	1 15 0	1 16 3	1 18 0	1 18 0	1 18 0	—	—	—	—
1917	} Prices Fixed												
1918													
1919	—	—	—	—	2 5 7½	2 14 4½	2 16 4½	2 14 0	2 13 4½	2 13 0	2 12 7½	2 11 9	—
1920	2 17 0	3 7 9	2 15 6	3 6 7	3 0 0	2 15 0	2 14 0	2 9 9	2 7 6	2 11 0	2 12 3	2 10 0	2 15 0
1921	2 1 0	2 0 1½	1 18 3	1 17 6	1 17 6	1 17 6	1 17 6	1 5 0	1 8 9½	1 7 9	1 7 0	1 7 0	1 18 8½
1922	1 6 7½	1 5 10½	1 6 11	1 7 0	1 7 0	1 7 0	1 7 0	1 5 3	1 4 2½	1 3 3½	1 2 6	1 2 2	1 5 2½
1923	1 2 9½	1 4 6½	1 5 2	1 4 8½	1 4 6	1 4 0	1 3 6	1 3 0	1 3 0	1 3 2½	1 4 9	1 3 10½	
1924	1 4 2½	1 4 0	1 4 0	1 3 7½	1 3 8½	1 3 6	1 2 11	1 2 6	1 2 1½	1 1 7½	1 2 3	1 2 6	1 3 1
1925	1 2 6	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 6	1 0 6	1 0 0	1 0 0	1 0 0	1 0 3	1 0 10½	1 1 1½
1926	1 1 1½	1 1 6	1 1 6	1 1 3½	1 1 3	1 1 5½	1 1 6	1 1 6	1 1 0	1 1 6	1 1 6	—	1 1 4½
1927	1 2 1½	1 2 3	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 7½	1 1 0	1 1 0	1 1 0	1 1 0	1 1 0	1 1 7½
1928	1 1 0	1 1 1½	1 1 11	1 2 4½	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 2½
1929	1 2 6	1 2 6½	1 2 11½	1 3 0	1 3 2½	1 4 0	1 4 6	1 4 8½	1 4 7½	1 4 6	1 4 6	1 4 3	1 3 7½
1930	1 3 3½	1 2 6	1 1 9	1 1 6	1 0 10½	1 0 0	1 0 0	0 19 6	0 19 0	0 17 4½	0 16 4½	0 16 4½	0 19 10½
1931	0 16 1½	0 16 0	0 16 0	0 15 11½	0 15 4½	0 15 0½	0 14 10½	0 14 6	0 14 6	0 16 8½	0 17 0½	0 16 6	0 15 9
1932	0 16 6	0 16 6	0 16 3	0 15 6	0 15 4½	0 15 0	0 14 11	0 14 3½	0 14 8½	0 14 6	0 14 0	0 14 9	0 15 1	0 15 3½
1933	0 15 6	0 15 3	0 15 3	0 15 3	0 15 3	—	—	—	—	—	—	—	—

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

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REGISTERED TRADE MARK

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

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ZETLAND ROAD, MIDDLESBROUGH.

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(A remittance should accompany instructions.)

SITUATIONS WANTED.

ADVERTISER, with 14 years' experience in iron-foundry management, desires a similar position where a sound practical and technical training can be made use of. Straight and special pipes, general engineering and non-ferrous castings.—Box 414, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

COMMERCIAL and Technical Foundry Engineer is open to consider executive position with a firm of repute. Last 15 years as director of large company and experienced in the development of foundry work. Capable of introducing new methods or reorganisation, costing, accountancy and general commercial work. Understands all branches of the foundry trades.—Write, Box 418, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY Representative, resident East Midlands, with sound connection, requires good line for the foundry.—Box 416, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

POSITION required as Foreman, Assistant Foreman or Assistant to Foundry Manager by young Moulder with sound practical experience. Secondary school education, good technical qualifications, age 30. Willing to go abroad. (214)

PROGRESSIVE position required by young man who has completed full-time course in foundry practice and has had melting and metallurgical experience with well-known foundry. (215)

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A FIRM manufacturing new speciality for the making of permanent patterns desire to appoint Agents on commission basis; those with good connection amongst foundries engaged in repetition work.—Apply, Box 420, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

PUBLICATION

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11 ACRES WORKS SITE.

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145,000 Sq. Ft. of Shops.

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WELL-BUILT & COMMODIOUS OFFICES

Will Sell whole or in lots to suit customers or Let on favourable terms. Unique opportunity for Manufacturers.

Apply—

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ALBION WORKS, SHEFFIELD.

BUSINESS FOR SALE.

RE GEORGE CAWWOOD & SON, LIMITED, WESTGATE FOUNDRY, ROTHERHAM

(In Voluntary Liquidation).

THE Liquidator of the above Company is prepared to consider offers for Purchase as a Going Concern of the old-established business of Ironfounders carried on by the above company.

The business, which is a very old-established one specialising in Railway-Wagon Castings, is situate close to the Westgate Railway Station, Rotherham.

Offers are invited now for the Purchase of the Freehold Land and Buildings, Goodwill, Machinery and Plant, Loose Tools and Patterns in One Lot as a Going Concern.

For further particulars or permit to view, apply, JOHN HANCOCK, Chartered Accountant, 57, Surrey Street, Sheffield.1.

MACHINERY.

SAND-BLASTING PLANTS; 20 complete plants in stock; supplied with or without air compressors; every plant rebuilt ready for use.—A. HAMMOND, 14, Australia Road, Slough.

PNEUMATIC MOULDING MACHINES

No. 9 "Ajax" Jolt Turnover.
"Wallwork" Squeezer, 17½-in. x 12½-in. boxes.
"Tabor" Portable Jolt Rollover.
Four No. 1 Britannia Jolters.

HAND MOULDING MACHINES

Eight Standard-size Adaptables with Tail Guides.
Two Large-size Ditto, with Star handle, turnover and adaptable draw frame.
"Coventry" Headpress Squeezer Table, 22 in. x 30 in.
Four 36-in. Farwell Type Universal Squeezers.

Also

Pneulec Sand-drying Plant. 1 ton per hour, Sand Mills, Disintegrators, etc.

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CROSSWELLS ROAD (Adjoining Railway Crossing), LANGLEY, Nr. Birmingham.

'Phone: Broadwell 1359.

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RUMBLER, 15′ long. x 4′ dia. x ¼″ thick.
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